The effectiveness of international climate finance in enabling low-carbon development: Comparing public finance and carbon markets

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Preface / Acknowledgments

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This thesis is dedicated to Sabine and Anise.

Executive Summary

This thesis analyzes how effectively international climate finance has reduced greenhouse gas (GHG) emissions in developing and emerging countries in the last 20 years. Furthermore, it identifies variables that influence the effectiveness of different channels. Two types of finance are studied in this context: (1) payments for carbon credits under the Clean Development Mechanism, a market-based approach under the Kyoto Protocol, and (2) grants from the Global Environment Facility (GEF), the official public finance channel under the United Nations Framework Convention on Climate Change.

In a first step, the study addresses the provision of resources, which is a precondition for effectiveness of international climate finance. It analyzes how different interpretation of "new and additional" finance, a common term in international decision texts, influences the level of climate finance. Understanding "new and additional" as "above current climate finance" would enhance the level of climate finance but it may lead to diversion of development assistance and is, therefore, not acceptable for developing countries. Two alternative interpretations of "new and additional" may better enable an increase in climate finance without diverting development assistance: "above pre-defined projection of development assistance and climate finance" or "from new sources". Climate negotiators may consider these definitions as promising compromises between the current positions of industrialized countries (no definition) and developing countries (above 0.7% of GNI flowing to development assistance).

In a second step, the study analyzes whether CDM and GEF have been as effective as they report in reducing GHG emissions via renewable energies. Using random effects, fixed effects and generalized methods of moment models, we estimate the determinants of renewable energy diffusion in more than 120 countries and conclude that both CDM and GEF tend to overestimate their influence on the diffusion of renewable energy power generation. Only on biomass power the CDM has the same or even a higher influence than officially declared, while results for geothermal and hydro power are not fully clear. These macro-level results are consistent with predictions derived from principal-agent theory as well as with past project-level evidence of support for business-as-usual projects by the CDM and the low quality of GHG assessments within GEF procedures.

In a third step, we analyze whether GEF and CDM influence the adoption of renewable energy policies, as the latter are key drivers of GHG emissions reductions via renewable energies. Using event-history models, we estimate that GEF and CDM have some (albeit limited) influence on adoption of "soft" policies, such as targets and framework policies, while no significant influence on costly policies, such as feed-in tariffs and other financial incentives can be observed in the short term. This lack of influence on financial incentives can be explained by the focus of GEF on capacity building and the potential fear of some developing countries that CDM may not support policy-financed projects. In this regard, the decision of CDM regulators to not punish countries for climate-friendly policies seems to have at least avoided a negative impact of CDM on renewable energy policy adoption.

In a final fourth step, the relationship between private finance and cost-effectiveness of international climate finance in reducing GHG is examined. While policy makers call for mobilizing as much private finance as possible in order to reach the goal to mobilize USD 100 billion per 2020, the empirical analysis of more than 300 CDM and GEF projects shows that this is not the most cost-effective strategy. While the analysis supports the finding of others that the private sector is more cost-effective than the public sector, it also finds that private finance intensity is far from perfectly correlated with cost-effectiveness. This is both because some cost-effective projects have very low private finance intensities (e.g. non-CO_2 reduction projects), and because the public sector is a major investor in climate-friendly technologies (e.g. in China). This means that selecting projects according to mobilization of private finance can only

improve cost-effectiveness in a situation where policy makers would otherwise not select the most cost-effective projects due to limited knowledge.

The results imply that international climate finance has to be reformed. Market-based mechanisms may have to move in the long-term from project-based payments (as under the CDM) to uniform carbon pricing (e.g. emission trading systems or country-wide carbon taxes), while public climate finance has to more consistently measure GHG reductions and provide clearer incentives for national climate policies, e.g. by prioritizing countries with ambitious low-carbon development plans. Finally, policy makers should be careful when focusing climate finance on mobilization of private finance as such a strategy may leave out some of the most cost-effective mitigation options.

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Abbreviations

2SLS	Two-stages least squares
AF	Adaptation Fund
AIJ	Activities Implemented Jointly
BAU	Business-as-usual
BB	Blundell and Bond model
CDM	Clean Development Mechanism
CEO	Chief executive officer
CIFs	Climate Investment Funds
CO_2	Carbon dioxide
CO_2-eq	CO_2-equivalents (GWP of other GHG transformed into GWP of CO_2)
COP	Conference of the Parties to the UNFCCC
DOE	Designated operational entity
EB	Executive Board of the Clean Development Mechanism
EE	Energy efficiency
EKS	Environmental Kuznet Curve
EU	European Union
ETS	Emission trading system
EV	Evaluation
FDI	Foreign direct investment
FE	Fixed effects
FIT	Feed-in tariff
GEF	Global Environment Facility
GCF	Green Climate Fund
GDP	Gross domestic product
GHG	Greenhouse gas
GMM	Generalized methods of moments
GNI	Gross national income
GWP	Global warming potential (100 years)
GWh	Gigawatt hour
IDA	International Development Association
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal rate of return
k	Thousand
LDCF	Least Developed Countries Fund
LL	log likelihood
Ln	Natural logarithm
LULUCF	Land-use, land-use change and forestry
MDB	Multilateral Development Bank
MLF	Multilateral Fund for the Implementation of the Montreal Protocol
M	Million
MRV	Measuring, reporting and verification
MWh	Megawatt hour
NAMA	Nationally Appropriate Mitigation Action
NPV	Net present value
OLS	Ordinary least squares
PD	Project document
PoAs	Programmes of Activities in the CDM

ppm	Parts per million
PPP	Power purchasing parity
NAMA	Nationally appropriate mitigation action
ODA	Official development assistance
OECD	Organization for Economic Co-operation and Development
R&D	Research & development
RE	Renewable energies (except in Figure 16, RE=random effects)
RPS	Renewable portfolio standard
SCCF	Special Climate Change Fund
SD	Standard deviation
SE	Standard error
t	Metric tons
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
USD	United States dollars
VIF	Variation inflation factor
WB	World Bank
WMO	World Metrological Organization

1 Introduction

Anthropogenic greenhouse gas (GHG) emissions are now widely seen as responsible for observed climate change, including the average warming of the surface (Solomon et al., 2007). Politicians have agreed in 2009 that global warming should not surpass 2 degrees above pre-industrial levels to prevent dangerous anthropogenic interference with the climate system (UNFCCC, 2009b). However, current actions taken on a national and global level are seen as not sufficient to keep global warming below 2 degrees (Rogelj et al., 2010), particularly because energy consumption and GHG emissions in developing countries are projected to rapidly raise (Hagem and Holtsmark, 2009; IEA, 2009a, 2010a).

An effective *international* climate regime is vital for achieving the politically set goals (Yamin and Depledge, 2004; Gupta et al., 2007)[1], given that a safe climate is a global public good (Kaul, 2003) and, therefore, nations cannot be expected to take action unilaterally. A key ingredient of effective international environmental regimes is financial support for developing countries (Biermann et al., 2012), in case of climate change both to reduce greenhouse gas emissions and to adapt to climate change. This financial support is often referred to as "climate finance" in the literature (Stewart et al., 2009; Buchner et al., 2011b; Haites, 2011; Michaelowa, 2012).

As there is no agreed definition of international climate finance (Buchner et al., 2011a), we define it here as *"international financial payments, directly or indirectly mobilized by industrialized country governments that cover costs of climate change mitigation and/or adaptation in developing and emerging countries"*. This definition does not only include public finance channels, such as the Global Environment Facility (GEF), but also payments via market-based mechanisms, such as the Clean Development Mechanism (CDM).[2] We use the term "developing and emerging countries" here as financial support in international climate policy has also been flowing to rapidly growing countries like China, Mexico, Russia and Thailand, to which the term "developing country" hardly applies any more. "Developing and emerging countries" are defined here as all countries without financial commitments under the United Nations Framework Convention on Climate Change (UNFCCC).

Not only mitigation actions but also the level of international climate finance is seen as substantially below the needs for keeping global warming below 2 degrees (World Bank, 2009; Roberts et al., 2010b; Olbrisch et al., 2011). Therefore, industrialized countries have committed themselves to increase the current level of climate finance from roughly USD 10-20 billion in 2010 to USD 100 billion in 2020 (UNFCCC 2009). Spending this finance effectively will be important to narrow the gap between business-as-usual GHG emissions and the 2-degree-path. For effective use, the lessons learned from the last 20 years of international climate finance may be important. Therefore, this study addresses the following main question: *how effectively has international climate finance reduced GHG in developing and emerging countries in the last 20 years, and which factors have determined effectiveness?*

Climate finance institutions are confident about their effectiveness: "*1 billion tonnes of CO_2 mitigated since 2004*" is a highlight of the recent CDM report (UNFCCC, 2012), while the GEF reports that its energy efficiency investments "*are expected to reduce carbon dioxide emissions by 1.3 billion tonnes by 2020"* (GEF, 2009b: 1), while its promotion of renewable energy shall result "*in an estimated direct avoidance of 290 million tonnes CO_2* (GEF, 2011c: 1)." Can researchers trust these numbers? Existing studies cast doubt on the

[1] While scholars agree that international coordination and agreements are key for climate policy, they disagree on whether the international regime should be regulated with a top-down approach (internationally agreed targets and timetables determining domestic actions) or a bottom-up approach (harmonizing and coordination of national actions), see Aldy and Stavins (2007).

[2] This definition differs from the one by Buchner et al. (2011b), who also include private investments that are not mobilized by governmental intervention, and the one by Michaelowa (2011b), who only includes public but no market-based sources in "climate finance".

reliability of these claims (see e.g. Eberhard et al., 2004; Michaelowa and Purohit, 2007; Mee et al., 2008; Schneider, 2009b), so a more thorough evaluation of effectiveness in reducing GHG seems to be warranted.

Studying past effectiveness of international climate finance does not start from scratch given the growing literature on the provision (e.g. Dellink et al., 2009; Harmeling et al., 2009; UN, 2010; Michaelowa and Michaelowa, 2011b), the governance (e.g. Ballesteros et al., 2010; Müller et al., 2010), and the spending and evaluation of climate finance (e.g. Mee et al., 2008; Alexeew et al., 2010; Donner et al., 2011). Therefore, this study focuses on four specific gaps in the literature.

The first gap refers to the provision of international climate finance, as one of the factors influencing effectiveness. While determinants of individual nations' contributions have been studied, both for public finance (Michaelowa and Michaelowa, 2011b) and carbon credits (Zhang, 2001; Jotzo and Michaelowa, 2002; Pinske, 2006; Flues, 2012), the relevance of international decision texts in the climate regime has only rarely been studied (e.g. Michaelowa and Michaelowa, 2011b). Specifically, no study has analyzed the term "new and additional" finance, which has been included in all major climate agreements (UNFCCC, 1992, 1997, 2001, 2009b) as developing countries requested that aid flows should not be redirected (Benedick, 1991; Bodansky, 2001; Chasek et al., 2010). The question is whether specific definitions of the term "new and additional" can help to increase the level of climate finance without leading to redirection of development assistance flows. This seems a particularly important question, as development assistance flows are still used to meet climate finance pledges, as criticized by NGOs and the media (Vidal and Adam, 2009; Oxfam Australia, 2012; Clarke, 2013). Additionally, industrialized countries have counted already planned or pledged climate finance as "new and additional" (Doyle, 2010; Oxfam, 2012). Therefore, a clear definition of the term seems to be warranted, and our first sub-question is: *How would the term "new and additional" have to be defined to enable an actual increase of climate finance without redirection of development aid (Research question 1)?*

The second gap refers to economic studies on cost-effective spending of climate finance. Generally the use of carbon price is seen as the most effective and cost-effective way to reduce GHG emissions (e.g. Pearce, 1991; Baranzini et al., 2000; Nordhaus, 2006; Stern, 2007), as the carbon market price should theoretically incentivize market participants to undertake the most cost-effective mitigation measures. Therefore, the CDM as a market-based mechanism is often considered as more cost-effective than public finance channels where incentives to lower costs are missing (e.g. Heller and Shukla, 2003). However, several micro-level studies have questioned the cost-effectiveness of the CDM as many projects – specifically renewable energies – may also have taken place without CDM support (Michaelowa and Purohit, 2007; Wara and Victor, 2008; Schneider, 2009a). These micro-level studies have left two questions open: first, whether the case-study results – that the CDM has in many cases not been effective in driving renewable energies – also apply on the macro level, which is ultimately of interest for the effectiveness of the climate regime, and second, whether public finance may have been more effective in the case of renewable energies, as it can also address information and regulatory barriers. Therefore, our second sub-question is: *How effective has the CDM been in reducing GHG emissions via renewable energy diffusion, and how effective has public finance been in comparison (Research question 2)?*

The third gap can be found in the literature on the effectiveness of international environmental regimes. This tradition stresses that effectiveness of international environmental regimes is, among other factors, closely determined by the implementation via national policies (see e.g. Haas, 1989; Keohane et al., 1993; Underdal, 1998). While national policies of developing countries are widely seen as important for reaching the 2 degrees target (Frankel, 2007; Michaelowa, 2007c; Den Elzen and Höhne, 2008), studies on the adoption of climate-friendly energy policies have focused on industrialized countries (Jacobsson and Lauber, 2006; Vachon and Menz, 2006; Huang et al., 2007; Matisoff, 2008). The few studies on RE policy adoption in developing countries have not examined the role of international climate finance (e.g. Benecke, 2009). However, international climate finance may be an relevant determinant of policy adoption: public finance actively aims at inducing renewable energy (RE) policies (GEF, 2011c), while market mechanisms can both form an incentive or disincentive for policies (Winkler, 2004; He and Morse, 2010). Thus, our third sub-question is: *Has international climate finance induced developing countries to undertake renewable energy policies (Research question 3)?*

The fourth and last gaps relates to the role of private finance. While scholars agree that the private sector will be needed for a large part of investments in low-carbon technologies (Lile et al., 1998; Zhang and Maruyama, 2001; Schmidt et al., 2008; Brinkman, 2009; Bowen, 2011; Olbrisch et al., 2011) and that the private sector is often more cost-effective in implementation (Dunkerley, 1995; Estache, 2001; Mueller, 2003; Pattillo, 2006; Hodge and Greve, 2007), no study has analyzed whether focusing climate finance on mobilizing private finance enhances effectiveness. Given potential trade-offs between the goals of climate policy makers (mitigation) and private investors (maximizing profits), mobilizing as much private investments as possible may actually reduce effectiveness of climate finance. This literature gap is particularly relevant as policy makers (EU, 2011; G20, 2011) repeatedly call for increasing the mobilization of private finance for climate change, which is in their self-interest as they have to reach the UNFCCC goal of mobilizing USD 100 billion of public and private finance per 2020. Therefore, the fourth sub-question is: *How does a focus on mobilizing private finance influence the cost-effectiveness and effectiveness of climate finance (Research question 4)?*

While the four research questions are, at first sight, independent from each other, there are important links: For instant, the provision of new climate-related resources (research question 1) is a prerequisite for effective promotion of renewable energies with public climate funding, examined by the second and third research question. Furthermore, the effectiveness in climate finance in promoting renewable energies (research question 2) may depend on the ability to promote related public policies (research question 3) and the mobilization of private investments (research question 4).

This study is structured as follows. The second chapter summarizes the history of and the key literature on international climate policy and climate finance to provide the relevant framework for the following analysis. Then, the literature on effectiveness of international climate finance is reviewed, explaining in more detail, why the four sub-questions are of particular relevance for climate finance effectiveness but have not yet been addressed. Also the strategies for answering the research questions are summarized: mainly, quantitative econometric models are used, but also qualitative data from the literature and semi-structured interviews (chapter 3). This is followed by four chapters addressing the four research questions; each of these chapters has a short introduction, method and data section, and discusses the results (chapters 4-7). A final chapter reviews the main findings and draws conclusions both for research and for policy-making.

2 International climate policy and finance: an overview

This chapter describes the historical evolution of international climate policy and finance, which is essential to understand the political shaping of existing climate finance mechanisms and their effectiveness. At the same time, for both climate policy and climate finance the most important research is summarized, in order to embed this study in the wider academic literature.

2.1 International climate policy

2.1.1 History

While there had already been first scientific evidence of rising GHG emissions and global warming in the 1960s and 1970s, it did not come on the international agenda before the mid to late 1980s. A 1985 scientific conference organized by the World Meteorological Organization (WMO) and the United Nations Environmental Programme (UNEP) in Villach concluded that global warming is highly probable and that governments should consider an international convention on climate change (Bodansky, 2001)[3]. In the coming years, many notable institutions, including NASA, recognized that global warming was happening, and the topic received substantial media and political attention. In 1988 the Intergovernmental Panel on Climate Change (IPCC) was founded by WMO and UNEP, with the role of summarizing the scientific evidence on climate change (Chasek et al., 2005). The 1990 first assessment report (Houghton et al., 1990) concluded that it is "certain" that human-induced greenhouse gas emissions enhance the natural greenhouse effect. The IPCC also concluded that man-made climate change will imply sea-level-rise and potentially substantial changes in ecosystems. A coalition of like-minded scientists, NGOs and European governments sharing a scientific consensus on climate change began pushing for an international protocol obliging governments to limit greenhouse gas emissions[4]. Official negotiations under the United Nations (UN) General Assembly began in 1991 and resulted in the Framework Convention on Climate Change (UNFCCC). The UNFCCC, signed at the UN conference on environment and development in Rio de Janeiro 1992, set the ultimate objective in Article 2 to "stabilize greenhouse gas emissions in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (UNFCCC, 1992). The UNFCCC did not include any clear commitment on emission targets and timetables as the United States (US) acted as veto power (Chasek et al., 2005).

The 1992 UNFCCC also spurred an early divide between industrialized and developing countries by establishing specific commitments for Annex-1 countries (industrialized countries and the former Eastern Bloc) in "taking the lead" in GHG emission reductions and advanced reporting (Article 4.2). Additionally, Annex-2 countries – industrialized countries excluding the former Eastern Bloc – took on the commitment to provide "new and additional" financial resources that cover costs of reporting obligations as well as mitigation and adaptation activities by developing countries (Article 4.3). The UNFCCC also included several principles that reflect the interests of developing countries, such as "common but differentiated responsibilities and capabilities", the "specific needs and special circumstances of developing country Parties" and the "right to sustainable development (Article 3). The division between Annex-1 and non-Annex-1 reflected the economic development and GHG emissions

[3] The relevance of the Villach conference for international climate policy to get on the political agenda is, however, contested (Franz, 1997).

[4] This coalition of like-minded scientists and policy makers is often called an "epistemic community" by political scientists (Gough and Shackley, 2001). Actually, Peter Haas, who shaped the term "epistemic community" (Haas, 1989), restricts the term to scientists that transmit scientific evidence to politicians (Haas, 2004).

per capita at the time of the convention but it also led to path-dependence (Castro et al., 2011a), as countries began to think and negotiate along this division, and no relevant developing country was added to Annex-1 in the last 20 years. The convention text specifically takes into account the interests of the large and growing developing countries Brazil, China and India, who were concerned about their right for economic development and wanted to avoid restrictions on their sovereignty, while the Small Island States did not reach their desired targets and timetables, and oil-producing countries could not block the adoption of the convention (Bodansky, 2001).

The UNFCCC entered into force after ratification of more than 50 states in 1994, and the first Conference of the Parties (COP) to the UNFCCC in Berlin 1995 created the Ad Hoc Group on the Berlin Mandate to negotiate a binding agreenment on actions to be taken after the year 2000 (Bodansky, 2001; Chasek et al., 2005), with a focus on strengthening industrialized countries' commitments, while additional commitments for developing countries were excluded (UNFCCC, 1995). The IPCC's second assessment report in 1996 strengthened the view that climate change mitigation was needed (Bodansky, 2001), influencing the negotiations under the Ad Hoc Group that resulted in the Kyoto Protocol 1997 that entailed binding targets for all Annex-1 countries to limit emissions of six greenhouse gases in the period 2008-2012, on average 5.2% below the 1990 level. The Protocol also contained three flexibility mechanisms to reduce costs of meeting these targets, including two mechanisms between industrialized countries (Joint Implementation and Emission Trading) and one mechanism for reducing emissions in developing countries (Clean Development Mechanism, CDM). The Kyoto Protocol is seen as a compromise between the US-led positions on low ambition and flexibility and the EU's and developing countries' position on high ambition and a focus on domestic actions (Oberthür and Ott, 1999; Bodansky, 2001).

The first years after Kyoto were filled by cumbersome negotiations on the accounting of emissions from land-use, land-use change and forestry (LULUCF), compliance procedures and the flexibility mechanisms, particularly the CDM. Several Annex-1 countries including the US, Australia, Canada and Russia threatened not to ratify the Protocol if their positions on liberal use of carbon sinks and the flexible mechanisms were not taken into account, clearly slowing down the negotiations (Chasek et al., 2005). Additionally, the chances for US ratification were considered low as the US Senate, whose approval was needed for ratification, already stated before Kyoto that it would not agree to any protocol unless it contained comparable commitments for developing countries. In 2001, the new US president George Bush made clear that his country would not ratify Kyoto. Nevertheless, the negotiations moved forward with the Marrakesh Accords at the 7th COP that clarified important details on the implementation, including the CDM. The Kyoto Protocol was seen as "ratifiable" at this time (Den Elzen and De Moor, 2002), and quickly the 55 needed nations ratified Kyoto until May 2002 (UNFCCC, 2012). However, it only entered into force in 2005, when Russia and thereby countries representing more than 55 per cent of Annex-1 GHG emissions had ratified (Henry and Sundstrom, 2007).

The period between 2005 and 2009 was characterized by substantial expectations that a more ambitious post-2012 climate regime might evolve. These expectations were nurtured by at least three factors. First, the publication of the Stern review for the British Government (Stern, 2007) changed fundamentally the way many economists and particularly politicians had been thinking about the economics of global warming: the Stern report argued that costs of climate change would be way higher than the costs of reducing GHG emissions and, therefore, substantial political action was required immediately. Before the Stern report, the standard economic view had been that uncertain costs of climate change and the high costs of mitigation only warranted very limited action (see e.g. Nordhaus, 1994). Second, the fourth assessment report of the IPCC in 2007 showed that the scientific community was even more certain that temperatures were increasing, mainly linked to man-made GHG emissions (Solomon et al., 2007) and that climate change would imply changing precipitation patterns, sea-level rise, melting of arctic ice, changes in ecosystems and substantial decrease of agricultural yields in some developing countries (Parry et al., 2007). The IPCC also received the 2007 Peace Nobel prize, together with Al Gore, which further increased media and public attention to climate change. Third, the negotiations themselves took a turn: at the 13th COP in 2007, Australia announced to ratify Kyoto and the Bali Action Plan (UNFCCC, 2008b) was adopted, establishing an Ad-Hoc Working Group for negotiating an agreed outcome on post-2012 climate policy until the end of 2009. In 2008, the EU endorsed an ambitious climate package and the rather climate-sensitive Democratic Party won the US elections. Thereby, the expectations of an ambitious climate treaty to be adopted in Copenhagen 2009 increased, although the world economy was in a recession.

The 15th COP in Copenhagen 2009, the largest climate summit ever, was plagued by sub-optimal political and administrative management, and could not meet the public expectations, as the US and larger emerging countries were not willing to commit to internationally agreed GHG targets. The conference only resulted in the "Copenhagen Accord" (UNFCCC, 2009b), a loose political agreement that was in the end not even formally adopted by the COP due to opposition by few developing countries, such as Tuvalu and Venezuela (Bodansky, 2010). While the Copenhagen Accord was considered a disappointment by researchers and most environmental NGOs who concluded that pledged emission reductions were way below the ones needed to limit global warming below 2 degrees (Rajamani, 2010; Rogelj et al., 2010), the perception was more positive in the US where e.g. Bodansky (2010) argued that the accord also included major achievements, such as the long-term 2 degree warming target, the pledging of substantial financial resources and some first moves to break down the "fire wall" between Annex-1 and non-Annex-1 countries, as major developing countries for the first time had pledged emission reduction actions under an international instrument, and had agreed to report more frequently on emissions and mitigation actions, while the latter were now either subject to international verification (financially supported actions) or to "international consultation and analysis" (domestic actions).

In the end, the Copenhagen outcome may have been below expectations but it set the cornerstones for the negotiations in the two coming years. In 2010, all elements of the Copenhagen Accord were included in the Cancun Agreements, and were formally adopted by the COP (UNFCCC, 2010). In 2011, the 17th COP in Durban, shortly disturbed by the withdrawal of Canada from the Kyoto Protocol, further clarified the Cancun agreements, e.g. by setting up the new Green Climate Fund and establishing a new market-based mechanism. Furthermore, the Ad hoc Working Group on the Durban Platform was established under which countries will negotiate "a protocol, a legal instrument or another decision with legal force" that shall be adopted by 2015 and should come into force not later than by 2020 (UNFCCC, 2011a). The Durban wording can be considered a small step towards a more ambitious climate regime, as the legal wording is more ambitious than in Bali, and as the new agreement should also include comparable commitments by developing countries. At the 18th COP in Doha, most European countries and Australia, together responsible for only 15% of global GHG emissions, committed to reduce their emissions by 18% below 1990 levels under a second commitment period under the Kyoto Protocol (2013-2020). Canada, Japan, New Zealand and Russia did not take on any new commitments. The carry-over of surplus emission allowances from the first to the second commitment period was limited to 2.5% of assigned allowances, to ensure that "hot air" allowances from Russia and other Eastern European countries are not endangering the environmental integrity of the Protocol. Furthermore, the Ad-Hoc Working Group on post-2012 climate policy was determined without any major new commitments on mitigation and finance. In the end, further work on increasing mitigation and finance ambition has been left to the Ad hoc Working Group on the Durban Platform that continues that will try to negotiate a new climate agreement until 2015.

2.1.2 Literature

How do political scientists and economists explain the slow but steady evolvement of international climate policy? The slow progress can be explained by theories on public goods. The avoidance of dangerous climate change is considered a global public good (see e.g. Kaul, 2003; Nordhaus, 2006), meaning that the consumption of this good is non-rivalrous (Samuelson, 1954), that no human can be excluded (Buchanan, 1965) and that this applies to all humans worldwide. The challenge with global public goods is that individual countries have low interests in providing the good on their own, as benefits accrue to all nations but costs are covered by the providing nation. Game theorist interpret climate change as a classical prisoners-dilemma game, where individual nations would be jointly best off when collaborating but they are individually always better off when not collaborating (Barrett, 2003). A different interpretation is that "atmospheric space for emitting greenhouse gases" can be considered a common pool resource (Ostrom et al., 1999). Hardin (1968) was the first to describe that such "commons" tend to be overused. Ostrom (1990) explains how institutions, such as decision-making procedures, monitoring, sanction and conflict resolution rules, have limited the overuse of common pool resources at the local and regional level. However, creating these institutions at the international level is far more difficult (Ostrom et al., 1999). Even among global public goods (or common resources), climate change is particularly challenging. Compared to the protection of the ozone layer hardly any cheap abatement technologies are available in case of climate change, no hegemonic power (such as the US or China) has interests in solving the problem, and the number of collaborating nations needed to create a net-benefit situation is particularly high (Barrett, 2003). Given that the governments of the most powerful nations have no interest in acting, neo-realist scholars in international relations (e.g. Waltz, 1979), can easily explain absence of any international progress on climate change, as they are assuming international anarchy and nations as uniform actors, so each country is assumed to have a unified position in international relations. However, how to explain that international agreements on climate change have nevertheless evolved and negotiations are continuing?

The gradual evolution of the climate regime is best explained by theories of liberal institutionalism (e.g. Krasner, 1983; Keohane, 1984), who assume that, even when international relations are generally anarchic, countries may have some interests in cooperation and are not uniform actors, as they are influenced by domestic politics. The interplay of domestic politics, including interest groups, and international negotiations have been studied theoretically (Putnam, 1988) and also empirically: in the climate change case where both a business and a environmental lobby exists (Michaelowa, 1998; Gullberg, 2008), and countries do not just follow their economic interests (Sprinz and Vaahtoranta, 1994). An additional theoretical contribution of liberal institutionalism is that it assumes that even weak institutions, such as the UNFCCC, will create norms and rules that can induce countries to cooperate. International climate change politics can be conceptualized as a regime, following Krasner's (1982a) definition of an international regime as "implicit or explicit principles, norms, rules and decision-making procedures around which actors' expectations converge in a given area of international relations". Yamin and Depledge (2004) and Depledge (2005) have described the very complex international climate regime that has evolved, including UNFCCC principles, procedures (e.g. the decision-making by unanimity) and expectations (e.g. the objective of stabilizing the GHG concentration in the atmosphere). The existence of this regime may explain why negotiations continue even when key countries have no interests in progress and find themselves in an economic crisis.

Some of the 'classic' theorists on cooperative action have recently urged to move the academic and political focus on climate policy away from the negotiations under the UNFCCC. Ostrom (2009) has called for polycentric governance of climate change, involving all geographical levels, while Keohane and Victor (2011) have found that climate change politics actually consists of a "complex of regimes" rather than a single international regime. Some other political scientists (Biermann et al., 2012) have argued that institutions at the international level for coping with environmental governance are deficient (e.g. there is no unified UN environment organization, no majority voting) and not enough financial resources for developing countries are available. Such financial resources are the topic within international climate policy that is specifically studied in the following.

2.2 International climate finance

In many of the climate negotiation summits mentioned above (e.g. Rio 1992, Kyoto 1997, Marrakesh 2001, Bali 2007 and Copenhagen 2009), climate finance – the financial resources for mitigation and adaptation in developing countries – have played a major role. In this chapter, we will further clarify the historic evolvement of international climate finance, the current situation (finance levels, sectors, GHG mitigation) and an overview of the literature.

2.2.1 History

Figure 1 depicts the history of international climate finance, both for public finance and market-based mechanisms. While this chapter focuses on the period 1992-2011, as shown in Figure 1, the understanding of climate finance also requires some background on earlier developments.

Already in the 1970s and 1980s, environmental issues were seen by developing countries as a threat for their development aspirations, as environmental protection was considered as additional financial burden that may slow-down the economic development path (Chasek et al., 2010). Developing countries also saw the North as primarily responsible for global environmental damage and, therefore, wanted the North to pay for any effort to abate global environmental pollution. Furthermore, developing countries feared that environmental concerns would be a new way for the North to dominate the South, e.g. by imposing environmental conditionality on aid flows. As consequence, developing countries asked the North to provide financial resources covering the costs of environmental treaty obligations of the South, as precondition for joining these treaties. Furthermore, the funding was also required to be “new and additional” to existing aid flows to avoid environmental conditionality and redirection of funding for development assistance (Chasek et al., 2010). The relevance of additional financial assistance was also nurtured by increasing environmental concerns, including climate change, in the 1980s (Fairman, 1996).

Financial assistance in the 1992 climate convention was, however, not only shaped by this long-term Southern perspective on global environmental politics but also by the concrete design of the ozone regime where financial assistance was essential for inducing developing countries to reduce ozone-depleting substances (Benedick, 1991; Luken and Grof, 2006). After the Montreal Protocol for the protection of the ozone layer was adopted in 1987, developing countries threatened not to ratify, if they were not compensated with resources “additional” to development assistance. This threat was relevant, as the projected rise of CFCs in developing countries could have offset any efforts achieved by developing countries. The South asked for coverage of all costs and channeling of resources through a new UN fund, while the US proposed to use existing funds under the World Bank (WB). The WB itself suggested the planned Global Environment Facility (GEF) as funding institution (Benedick, 1991). The compromises in the 1990 London Revisions to the Montreal Protocol were, first, to cover not all but only the “incremental” costs; second, to make sure that the most cost-effective technologies were used and, third, to establish a new “Multilateral Fund” under UNEP but use the World Bank as most important implementing agency. Furthermore, the term “additional” was kept but not clearly defined.

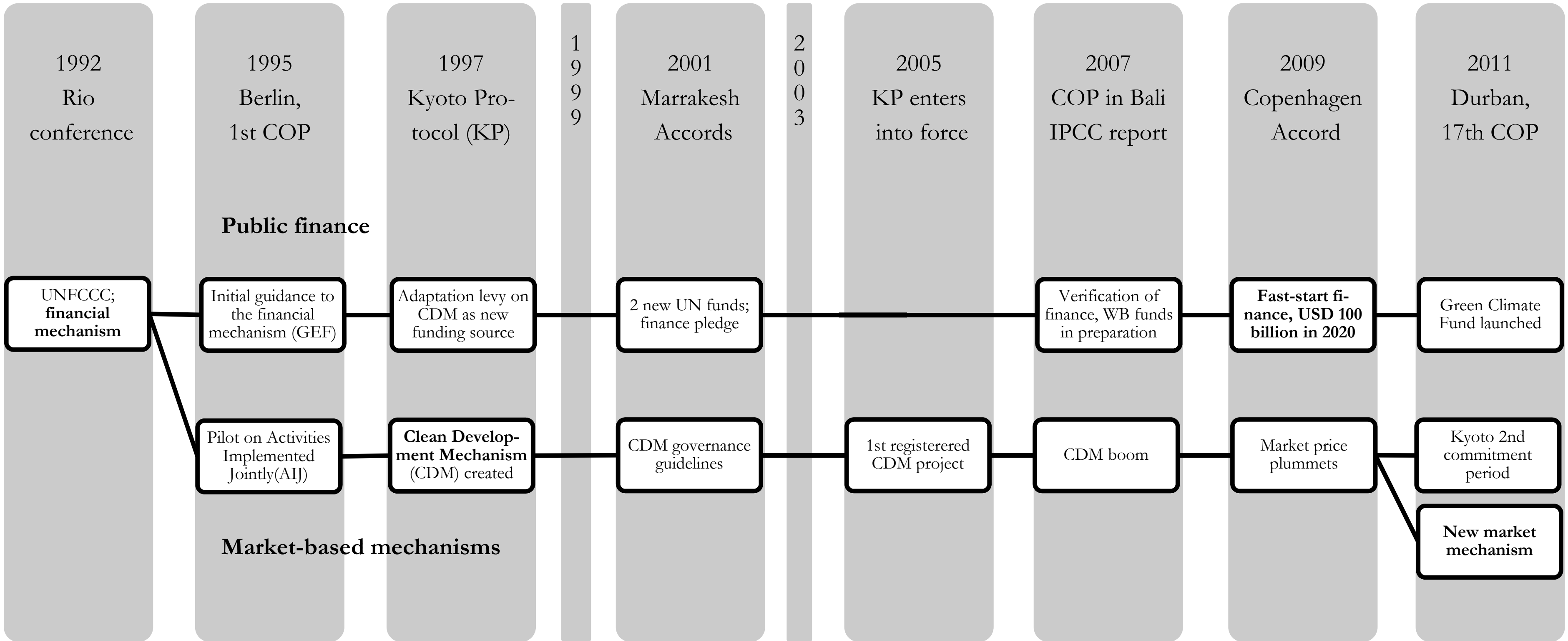
The US wanted to set not precedent for the much larger costs of climate change so the wording "without prejudice to any future arrangements that may be developed with respect to other environmental issues" was included in the London Amendments to the Montreal Protocol 1990 (Benedick, 1991).

During the negotiations of the 1992 FCCC, the same crunch issues on financial assistance as in case of the ozone regime emerged (Bodansky, 2001): First, the South wanted all costs of its obligations to be covered by the North. Second, developing countries requested a new fund to be established as in the ozone regime, while industrialized preferred the GEF, who was established in 1990 by the World Bank and just underwent a pilot phase involving various implementing entities, such as the UN Development Programme (UNDP) and UNEP. Third, developing countries demanded that financial resources should be "new and additional" to existing development assistance pledges.

The final UNFCCC (1992) text on finance was a compromise of Northern and Southern positions (Bodansky, 2001). First, industrialized countries committed themselves to provide financial resources covering the full incremental costs of developing country mitigation commitments[5] but only the costs *as agreed* between developing countries and operational entities of the financial mechanism (Article 4.3). This wording has been interpreted as being the same as in the Ozone case where industrialized countries pay all incremental costs of developing countries (Biermann, 1997) but developing countries mitigation commitments have been kept very vague in the UNFCCC (Article 4.1.), so the financial mechanism's operational entity received substantial power in shaping the agreement on incremental costs. Second, the GEF was made operational entity of the financial mechanism but only on an interim basis and it was asked to be restructured (Article 21). As concession to industrialized countries, financial resources could also be provided as concessional loans and through other bilateral, regional and other multilateral channels (Article 11). Finally, the term "new and additional" was included but no further definition given (Article 4.3). The term left open whether an increase of development assistance with climate co-benefits – as already provided in the 1980s (Roberts et al., 2009; Michaelowa and Michaelowa, 2011b) – would count as "new and additional". As concession to developing countries, a further article (4.7) clarified that the implementation of developing country commitments will depend on the effective provision of financial and technological support.

[5] These commitments included mitigation and adaptation programs, national GHG inventories, technology cooperation, research, and information exchange, all of which were very loosely defined (see Article 4.1. of the UNFCCC, 1992).

Figure 1: History of international climate finance



Source: own compilation; WB = World Bank

After the Rio conference, where GEF also became interim financial mechanism of the biodiversity convention[6], GEF was restructured, receiving a very complex structure that balanced the interests of international organizations (World Bank, UNDP, UNEP), developed and developing countries and the civil society (Fairman, 1996). Administratively, the GEF secretariat remained part of the World Bank, which also acts as trustee of GEF funds, but the GEF received an independent governance structure with a council where developing countries had more voting power than in the World Bank but less than under UN institutions. With this set-up, the World Bank and industrialized countries retained some of the power asymmetry compared to other implementing agencies and developing countries (Streck, 2001). The politically shaped setup of the GEF also led to a complex approval process that is often perceived as cumbersome and lengthy (Werksman, 1998; Streck, 2001; Birner and Martinot, 2005). In 1995, the first COP of the UNFCCC decided to continue using GEF as interim operational entity of the financial mechanism (Bodansky, 2001), gave initial guidance to the GEF (see Figure 1) and in 1996, a Memorandum of Understanding between the COP and the GEF council was adopted clarifying the respective roles (UNFCCC, 1996)[7]. The resulting structure, where the COP gives guidance to the GEF, but the GEF council is formally responsible for decisions, and is dependent on quasi-voluntary contributions by industrialized countries[8], resulted in continuing frustration by developing countries who argue that the GEF does not fully take into account the COP guidance, is underfunded and slow (Werksman, 1998). These points of criticism have stayed alive in developing countries' positions on GEF for a long time, as reflected by the following G77 statement: "The GEF lacks adequate resources and requires the simplification of its procedures (G77, 2007: 2)."

From 1995 on, a strand of more market-oriented resources began to emerge in the climate regime (see lower part in Figure 1). The first COP in Berlin decided to establish a pilot on "Activities Implemented Jointly" (AIJ), where countries could implement activities in other countries, including in the South. This AIJ program was based on concerns of countries like Norway and Japan, for which domestic GHG emissions reductions were costly. As concession to developing countries who opposed non-domestic implementation of UNFCCC commitments, it was not allowed to credit emission reductions under AIJ activities (Bodansky, 2001). During the negotiations of the Kyoto Protocol in 1997, the US wanted to include an AIJ-type mechanism for meeting reduction obligations abroad, which was strongly opposed by developing countries and initially the EU. On their side, developing countries pushed for additional financial resources, disappointed by decreasing development flows after Rio (Chasek et al., 2010) and the low GEF climate change funding (Werksman, 1998)[9]. Under this public finance perspective, Brazil proposed a Clean Development Fund, sourced by fees for non-compliance with emission targets. In the final negotiation round, the Clean Development Fund was transformed to the "Clean Development Mechanism" and the fees were replaced by the possibility to avoid non-compliance by achieving reductions in the South, essentially what the US wanted (Cole, 2012). Finally, in exchange for deleting a sentence on "voluntary commitments" by the South and the earmarking of CDM fees for adaptation funding, developing countries gave up their opposition against the flexibility mechanisms, and the CDM emerged as the "Kyoto surprise" (Werksman, 1998; Oberthür and Ott, 1999). The two main purposes of the CDM reflect the respective interests of developing and developed countries when setting up the

[6] Later, GEF also became the financial mechanism of the Stockholm Convention on Persistent Organic Pollutants (2001) and of the Desertification Convention (2003), while also supporting economies in transition to meet their obligations under the Montreal Protocol (GEF, 2012).

[7] In 1998 the GEF became permanent operational entity of the financial mechanism but the latter was to be reviewed every 4 years (Oberthür and Ott, 1999).

[8] The fact that there is no strict financial obligations for providing finance to GEF, gives contributors a stronger role than the actual voting shares in the GEF council suggests, e.g. one of the key contributors threatened to withdraw GEF funding if no result-based allocation formula was had been adopted (according to one interviewee, see Annex 10.1). In contrast, recipients may fear that they lose funding if they veto decisions in the GEF council.

[9] In the three years before the Kyoto conference USD 400 million were approved, see GEF (1997).

CDM: the first goal is to assist developing countries in achieving sustainable development and contribute to emission reductions[10], while the second goal is to help developed countries in achieving their Kyoto targets in a cost-effective manner through emission credits from projects in developing countries.

The Marrakesh Accords at the 7th COP in 2001 (UNFCCC, 2001) strengthened both the institutions for market-based resources and public finance (see Figure 1). On the market-based side, details on the CDM were clarified, which included the functions of the CDM Executive Board (EB) as the main supervising body, who received the tasks to approve new baseline and monitoring methodologies, register projects, issue "Certified Emission Reductions" and accredit operational entities, which were tasked to validate project design documents and certify monitored emission reductions. Furthermore, host countries of CDM projects were tasked to designate a national authority that has to approve CDM projects prior to validation. Furthermore, important terms such as "baseline", "leakage" and the "crediting period" were defined. On the public finance side, GEF was urged to provide more funding for capacity building, and industrialized countries committed to provide funding via an increased GEF replenishment, bilateral and multilateral sources and via two new funds, the Special Climate Change Fund (SCCF) for adaptation, technology transfer and diversification of fossil-fuel-dependent economies, and the Least Developed Countries Fund (LDCF), supporting mainly adaptation. GEF was entrusted to operate both the SCCF and the LDCF. The COP also welcomed that the European Union, Canada, Iceland, New Zealand, Norway and Switzerland had declared their preparedness to jointly contribute USD 410 million by 2005, the first time concrete financial volumes were pledged under the climate regime. This funding was meant to come from GEF, SCCF, LDCF, the Adaptation Fund and further bilateral and multilateral sources, and was said to be beyond the level of 2001. Later, it proved to be impossible to verify whether the pledge was met as the 2001 funding level was simply not known (Pallemaerts and Armstrong, 2009), which led to calls for better monitoring, reporting and verification of financial flows (e.g. Müller, 2009).

The CDM quickly emerged after the Marrakesh Accords. The CDM EB began to meet on a regular basis, set up supportive panels and working groups, approved the first baseline and monitoring methodologies in 2003, accredited first operational entities 2004 (UNFCCC, 2004) and a hydro power station in Honduras became the first registered project in January 2005 (URC, 2011). The Kyoto entry-into-force in 2005 led to a "gold rush" in the international carbon market. All industrialized countries that ratified the Kyoto Protocol – except the former Eastern bloc countries who had excess emission allowances – planned to use CDM credits to fulfill their emission targets. Mainly promoted by the establishment of the EU emission trading system (EU ETS) that allowed for using CDM credits, the CDM quickly became an important pillar of the climate regime with thousands of projects registered and billions of dollars for CDM credit purchases contracted (URC, 2011; Michaelowa and Buen, 2012).

For public finance, the next important step was the 13th COP in Bali 2007 (UNFCCC, 2008a), where the governance of the Adaptation Fund (AF) was decided, and where finance played a crucial role under the Bali Action Plan. In case of the AF, the newly created AF Board, in which developing countries had majority of seats, became the operating entity of the AF under authority of the COP, while the GEF was invited to provide secretary services and the World Bank became the trustee. This solution was a compromise between the interests of developing countries who were disappointed about GEF governance and wanted a COP-led fund, while industrialized countries preferred GEF as operational entity. As concession to developing countries, they were allowed to directly submit proposals to the AF, and did not have use multilateral agencies (e.g. World Bank, UNDP, UNEP) as intermediaries, as in case of the GEF. Under the Bali Action Plan (UNFCCC, 2008b), finance was at the edge of a last minute decision: industrialized countries achieved that a future outcome would include "nationally appropriate mitigation actions" (NAMAs) by developing countries, who should be "measurable, reportable and

[10] The official wording is "contributing to the ultimate objective of the Convention" (UNFCCC, 1997: Article 12.2).

verifiable" (MRV). However, developing countries insisted that NAMAs are to be supported by finance, technology and capacity building, and that MRV also applies to support. MRV of both actions for developing countries and financial support was considered a major step forward in the climate regime (Winkler, 2008).

In the years between 2007 and 2009, bilateral and multilateral agencies began to set up a range of funds and initiatives for mitigation and adaptation actions in developing countries, e.g. the German International Climate Initiative or Australia's International Forest Carbon Initiative (HBS/ODI, 2011). The most relevant development was the setup of the USD-6-billion Climate Investment Funds (CIFs), which were administered by the World Bank. The CIFs were composed of different funds for clean technologies, renewable energies in low-development countries, adaptation and forestry, while regional development banks were used as implementing agencies. The CIFs were considered as an attempt by developing countries to have more decision power and undermine the new governance experiment under the AF (Müller and Winkler, 2008). The CIF initiators were aware of the political salience so the governance framework of the Clean Technology Fund, the largest CIF, made clear that it will not "prejudice the on-going UNFCCC deliberations" and that the fund should conclude its operations once new financial architecture is effective (CIF, 2008). Furthermore, the CIFs' governance structure resembled the GEF one (apart from the CIFs' independence from the UNFCCC), with balanced representation of industrialized and developing countries in the trust fund committees, consensus decisions and windows for civil sector participation (Ballesteros et al., 2010). Several experts (Müller and Winkler, 2008; Ballesteros et al., 2010) agreed that the strategy of the CIFs to support national climate policy frameworks was a positive move in the direction of the alignment and ownership principles of the Paris Declaration on Aid Effectiveness. By the end of 2011, the CIFs have received more than USD 4 billion, and approved more than USD 2 billion of funding (CIF, 2011a), while their future is still unclear.

The Copenhagen Accord 2009 (UNFCCC, 2009b), although not formally adopted by the COP, had a substantial outcome from a climate finance perspective (see bold text in Figure 1), mainly in four ways. First, delivery of all financial resources were said to be measured, reported and verified, meaning that MRV did not only apply to NAMA support as under the Bali Action Plan. Second, industrialized countries committed to USD 30 billion of "new and additional" resources for the period 2010-2012, the so-called fast-start finance. Third, there was a further commitment to mobilize USD 100 billion of financial resources per year in 2020, usually called "long-term finance". The funding was said to come from a variety of sources, including private ones, and a high-level panel was established to identify promising sources. Finally, a new Green Climate Fund (GCF) was set up as additional operational entity of the financial mechanism. Interestingly, the CDM and new market mechanisms were not mentioned once in the Copenhagen Accord, although the definition of the USD 100 billion let open whether market mechanisms are included or not (Roberts et al., 2010b).

The finance decisions of the Copenhagen Accord were all included in the Cancun Agreements 2010 (UNFCCC, 2010) and, therefore, formally adopted by the COP. The Cancun Agreements also further specified MRV of support and established a new Standing Committee that should support the COP in improving coherence and coordination in the delivery of climate change financing, rationalization of the financial mechanism, finance mobilization and MRV of support. As well, the cornerstones for the new GCF were set, by deciding on equal representation of developed and developing countries on the GCF board, inviting the World Bank to be interim trustee and establishing a committee designing the fund. On the sources of long-term finance no progress was made, although the UN High Level Panel's report concluded that reaching the USD 100 billion is challenging but feasible, when considering different sources, ranging from traditional budget sources, development bank finance, carbon taxes, and international transport levies to auctioning of carbon credits (UN, 2010).

At 16th COP in Durban 2011, both negotiations on public finance and market-based mechanisms slightly progressed (see Figure 1). In case of market-based mechanisms, the COP – after more than three years of discussions – finally decided to establish a new market-based mechanism (UNFCCC, 2011a), which was pushed by the EU and other industrialized countries to link the international carbon market to own contributions of developing countries, and to move from the project level (as in the CDM) to a sectoral or even national level (see e.g. Sterk and Wittneben, 2006; Schmidt et al., 2008; Schneider, 2009a for related proposals). However, it remained unclear from where demand for new market mechanisms should come from, as no major demand was expected to emerge from the 2nd commitment period under the Kyoto Protocol, which was also agreed upon in Durban (UNFCCC, 2011b). With regards to public finance, the GCF was launched by adoption of a governing instrument, which included some innovative features such as direct access, result-based payments and a private sector facility. Furthermore, a work program on long-term finance was established, as parties could not agree on any details regarding the USD 100 billion goal. Finally, the standing committee was tasked to conduct a biennial overview of the climate finance flows. Such an overview may have become vital as the 20-year history led to scattered international climate finance, nowadays flowing via GEF funds, the AF, CIFs, a variety of bilateral and multilateral channels, and in the future also via the GCF. In Doha 2012, the work program on long-term finance was extended but no formal decisions on the amount of finance in the years 2013-2015 was reached, even when few EU countries announced increased contributions.

2.2.2 *Level of funding, sectors and reported GHG emission reductions*

The just described history of international climate finance has led to a complex landscape, involving both public finance and market-based payments. In the following, a short overview is given, on the level of funding, the sectoral focus and the reported GHG emissions reductions. We only refer to finance for climate change mitigation and neglect adaptation finance in the following, as this thesis focuses on the effectiveness in reducing GHG emissions.

Level of public funding

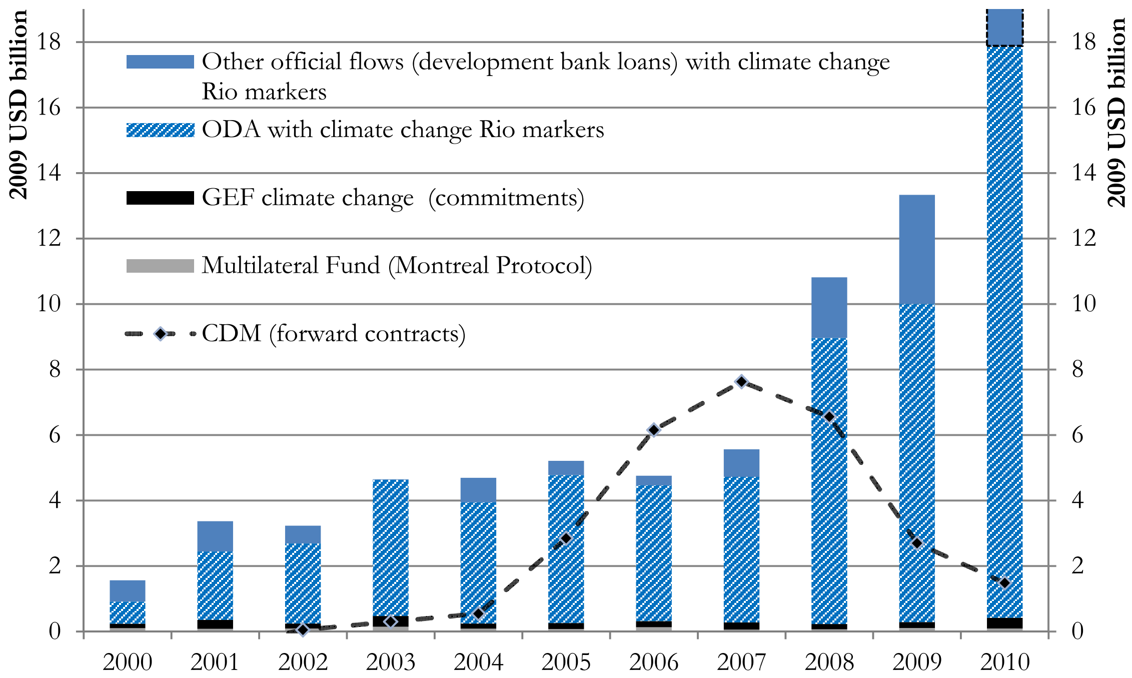
While new Green Climate Fund may become more important in the future, the GEF is still the only operational entity of the UNFCCC's financial mechanism that has disbursed climate change mitigation funding (see Figure 2); in the period 1992-2008 more than USD 2.5 billion have been committed for climate change mitigation (GEF, 2009a) and further 1.35 billion USD have been pledged for the period 2010-2014 (GEF, 2010a).

Even if the GEF has been operating the UNFCCC's financial mechanism in the last 20 year, most public climate finance for developing countries have flown through other channels (see Figure 2). According to the Organization for Economic Co-operation and Development (OECD)'s climate change Rio marker coding more than USD 16 billion of Official Development Assistance (ODA) have been committed to projects with climate change mitigation as principal or significant objective in 2010 (OECD, 2011a). This is a sharp increase compared to 2009 and previous years, probably a result of the "climate year" 2007 (IPCC 4th Assessment Report, Peace Nobel Prize, Bali Action Plan), the setup of the CIFs in 2008 and the USD 30 billion fast-start finance commitments for the period 2010-2012.

It has to be noted that the surge of reported funding after 2007 (see Figure 2) may not only relate to factual increases in climate funding but also to low data quality in earlier years and increased pressure over time to report climate change action (Roberts et al., 2009; Michaelowa and Michaelowa, 2011a)[11]. Projects marked as having "climate change" as objective may not have necessarily been undertaken because of climate change reasons. Michaelowa and Michaelowa (2011b) found that the share of RE and energy efficiency projects in overall ODA is mainly connected to the oil price and hardly to major climate change agreements, such as the UNFCCC or the Kyoto Protocol.

The reported numbers of climate ODA as shown in Figure 2 do not include funding from the Multilateral Fund for the Implementation of the Montreal Protocol (MLF), whose programs – although aiming at reducing ozone-depleting substances – have substantial climate change mitigation benefits (Luken and Grof, 2006). The OECD (2011a) has included 100% of the Multilateral Fund in "multilateral aid to climate change", but the MLF's future contribution to climate change is uncertain, as developing countries may use low-cost but climate-unfriendly HFCs in their plans to phase out HCFCs under the Montreal Protocol (Shende, 2010).

Figure 2: International public and market-based climate change mitigation finance (reported commitments)



Sources: OECD (2011b) for GEF and other international public climate finance (climate-coded ODA and multilateral loans). The numbers are the climate-related flows as reported by public institutions. While an increase of public climate-related finance may have happened after 2007, part of the increase may be due to politically motivated changes in reporting (see main text). For other official flows, data on climate change coding is not yet available for 2010 (see column with dashed line at the right). Source for CDM forward credits is Linacre et al. (2011).

Level of market-based funding

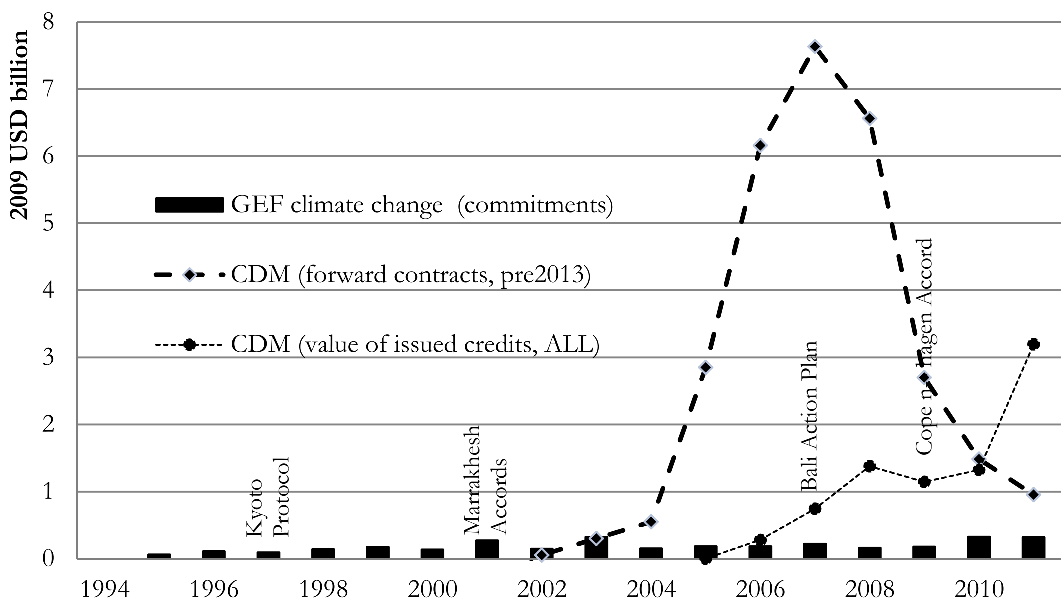
When the Kyoto Protocol came into force in 2005 and the EU ETS started its operations, the contracts for CDM credit purchases rapidly increased to several USD billion a year (see Figure 3). The value of

[11] The OECD removed numbers for the climate change Rio markers prior to 2007 from their website, officially because data for the years 1998-2006 were obtained on a trial basis and reporting became only mandatory with 2007 flows (OECD, 2012c) but the removal of the data may also be related to the coding errors found in the data (Michaelowa and Michaelowa, 2011a).

such contracts even surmounted total ODA with climate change objectives in both 2006 and 2007. From 2008 on, both CDM contracts and the carbon market price crashed due to the economic crisis and uncertainty on post-2012 climate policy. As the planned US cap-and-trade system was not approved by the US senate and the Copenhagen climate summit in 2009 did not result in binding emission limitations for post-2012, the interest in signing new CDM contracts declined even more in 2010.

Despite the decline in CDM contracts in recent years, the actual CDM finance flowing North-South is still increasing. This is because most CDM contracts foresee payment upon delivery of credits, and new CDM credits have reached an all-time high in 2011, with credits representing 320 million tonnes of CO_2 issued by the CDM EB (URC, 2011). The corresponding value of the 2011 credits is approximately USD 3.2 billion, when assuming an average price of 10 USD per credit. This credit price of 10 USD is approximately the average primary credit prices reported for the years 2004-2009 by GIZ (2011) and the World Bank carbon market reports (Lecocq and Capoor, 2005; Capoor and Ambrosi, 2006, 2007, 2008, 2009, 2010). Some of the credits, particularly from unilateral CDM projects with no industrialized country partner (Michaelowa, 2007b), may have directly been sold on the spot market, where it would have fetched prices above USD 10 before mid-2011, and lower ones since then.

Figure 3: Climate change mitigation finance under UNFCCC mechanisms between 1994 and 2011



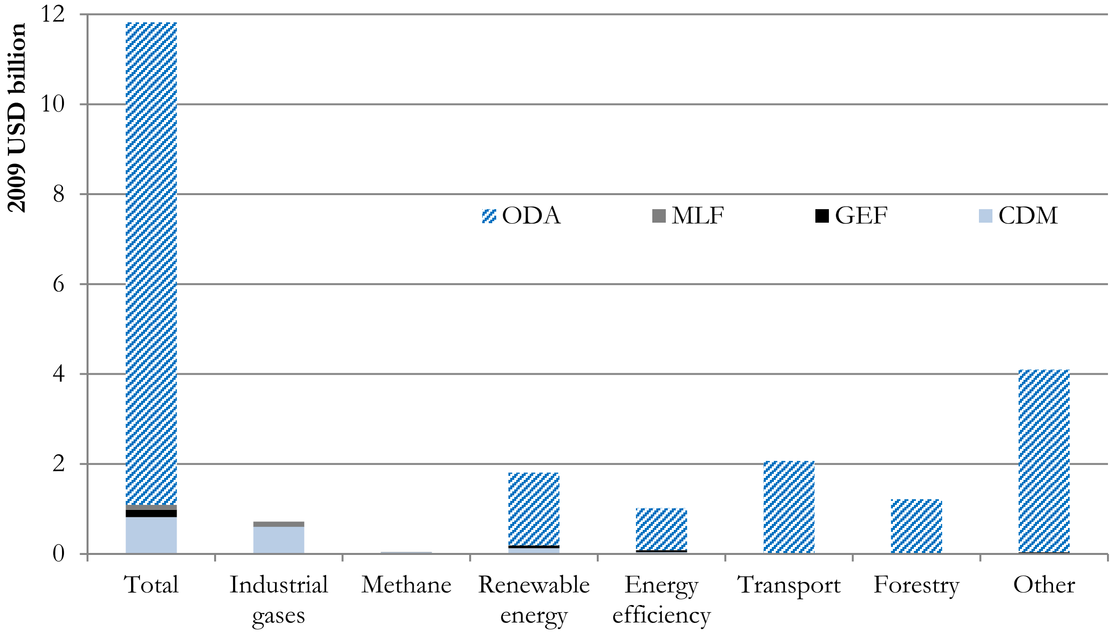
Sources: OECD (2011b) for GEF until 2010; GEF (2010a) for GEF 2011 figure; URC (2011) for issued credits, while assuming 10 USD as credit value; Linacre et al.(2011), Kossoy and Guigon (2012) for CDM forward contracts.

Among UNFCCC-related mechanisms, the CDM as a market-based instrument has clearly become more important than the GEF as a public finance instrument (see Figure 3). In terms of funding commitments, the value of CDM forward contracts has overtaken GEF commitments already in 2004, while in terms of disbursements, CDM funding (value of issued credits) surpassed GEF funding in 2006. The supremacy of market mechanisms under the UNFCCC may, however, vanish in the next few years, as major funding commitments are foreseen for the Green Climate Fund as second operational entity of the UNFCCC's financial mechanism, while no substantial new demand for credits under the CDM and the new market-based mechanism are in sight, as the economic downturn has drastically reduced the demand for carbon credits, and no industrialized country currently seems to be willing to step-up its 2020 mitigation target.

Funding per project type

Figure 4 displays the level of funding per project type according to official project documents. In case of CDM, the funding has been calculated by multiplying the amount of issued credits with 10 USD (same credit price assumed for all project types)

Figure 4: Funding per project type (2008-2010, average)



Sources: GEF Data from Stadelmann (2009), which is based on numbers in the official GEF documents (GEF, 2011a). The transaction costs (agency fees, GEF secretariat) are not included here; CDM funding is calculated as issued credits in tCO_2 (URC, 2011) multiplied by an estimated credit price of 10 USD per tonne of CO_2, which is based on primary credit prices reported by GIZ (2011) and the World Bank carbon market reports (Lecocq and Capoor, 2005; Capoor and Ambrosi, 2006, 2007, 2008, 2009, 2010); the average of the years 2004-2009 is taken; MLF numbers from UNEP (2012); ODA numbers from OECD (2011b), excludes GEF and MLF

CDM has focused on industrial gases – GHG other than CO_2 and methane in the industrial sector (75% of issued credits until 2010) –, while renewable energies (15%), energy efficiency (5%), methane-reducing projects (5%) have been other relevant sectors. In the future, renewable energies will even have a higher share of issued CDM credits as they represent 68% of registered projects and 35% of expected credits until 2012 (URC, 2011). Finally, no credits for forestry projects have been issued until the end of 2010.

GEF funding has focused on renewable energies and energy efficiency in the buildings, industry and energy sector (each 30-40% of funding), while 7% has been spent on energy efficiency in the transport sector. Only around 1% of funding has been used to reduce methane emissions in the waste and agriculture sectors, and also reduction of industrial gases and funding for afforestation and reduced deforestation has been negligible. However, new GEF funding for forestry is foreseen for the period 2010-2014 (GEF, 2010a).

The MLF has uniquely focused on industrial gases, consistent with its main aim to support developing countries in phasing out ozone-depleting substances.

ODA (other than GEF) funding with reported climate benefits has also focused on transport (21%), renewable energy (16%), energy efficiency and fuel switching (9%), while forestry (11%) is also a major sector. Given that many of these have been project types in ODA for a long-time, it is questionable whether these projects are indeed undertaken for climate purposes. Around 44% of climate-marked ODA cannot be attributed to a mitigation-related project type, either because it is cross-sectoral finance or because it is actually climate change adaptation finance that has been miscoded (see Michaelowa and Michaelowa, 2011a).

GHG emissions reductions overall and per project type

The GEF and CDM are the only two institutions that publish information about GHG emissions reductions of each of their projects. In case of GEF, GHG emissions reductions are reported as projections in the project documents, while in case of the CDM, GHG reductions are even verified and certified. Reported effectiveness in tonnes of CO_2-equivalents (tCO_2-eq) per year has been similar for CDM and GEF until 2010 (see Figure 5). From 2011 on, the overall GHG emissions reductions reported by the CDM should be higher than GEF, as CDM credit issuances are rising, while GEF funding has remained constant over time (see Figure 3).

In case of public funding that is not channeled through the GEF, no information on GHG emissions reductions is available, as other ODA projects do not regularly report on this. Only for the MLF, GHG emissions reductions have been estimated. Although the MLF has no specific climate change aims, it may have reduced around 70-115 million tCO_2-eq per year (UNEP, 2012), which is similar to the annual GHG emissions reductions of GEF and the CDM between 2008 and 2010. However, the GHG emissions reductions of the MLF will be comparatively lower in the future, both because the GHG emissions reductions via CDM are rising, and because of the threat that developing countries may use climate-unfriendly HFCs in their plans to phase out HCFCs under the Montreal Protocol (Shende, 2010)[12].

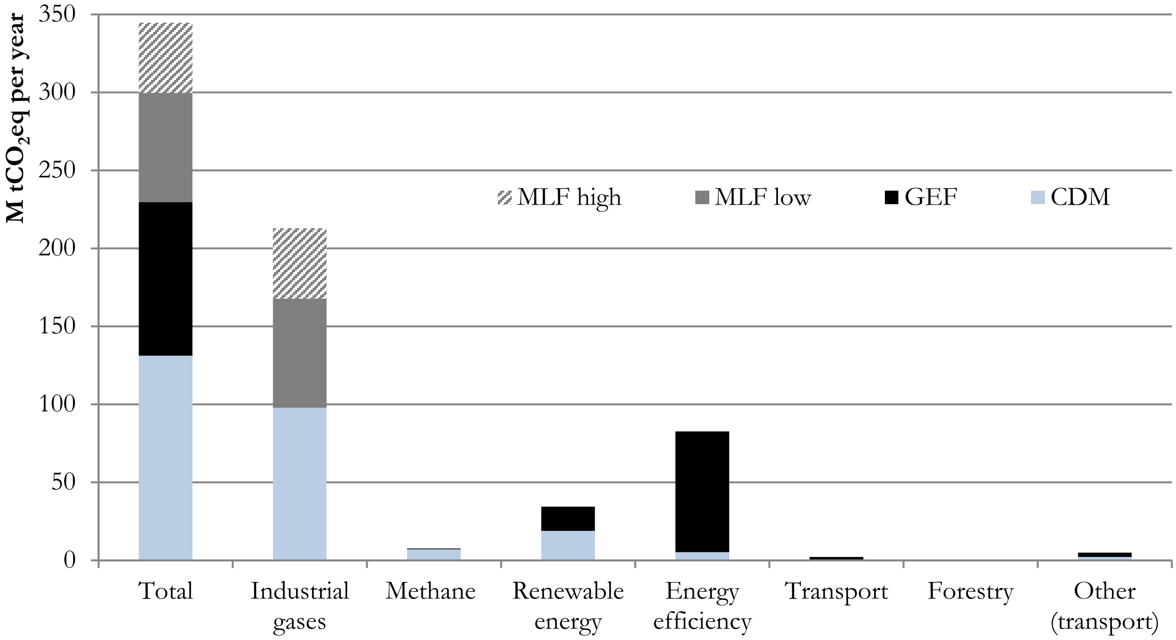
On a sectoral basis, GEF has clearly reduced more GHG in energy efficiency (including the transport sector), while the CDM did better in reducing industrial GHG and methane emissions. The respective sectoral advantages may be overestimated, however, as GHG emissions reductions via GEF energy efficiency projects are not thoroughly verified (Mee et al., 2008; Stadelmann, 2009) and reductions of industrial GHG in the CDM have probably been overestimated as some installations may have artificially inflated their production of HCFC-22 to claim higher reductions of HFC-23 (CDM Watch, 2010; Schneider, 2011). Nevertheless, it is very likely that the GEF has reduced less industrial GHG – it has simply not been a political strategy – and that the CDM has been less successful in promoting energy efficiency, as it cannot address the information asymmetries and barriers in this sector (Koeppel and Ürge-Vorsatz, 2007), and CDM transaction costs are too high for small projects (Hinostroza et al., 2007; Karakosta and Askounis, 2010).

The most interesting project type from a comparative point of view is renewable energy (RE): while GEF and CDM report to have reduced a similar amount of GHG emissions via renewable energies per year until 2010 (see Figure 5) the CDM's reported GHG emissions reductions via RE have overtaken the ones of GEF in 2011, when CDM credits representing 74 million tonnes of CO_2 have been issued for RE projects (URC, 2011). However, several studies have found that CDM's GHG emission reductions

[12] Therefore, the MLF programs now encourage countries to use low-carbon replacement gases (Multilateral Fund, 2012)

via renewable energies are substantially overestimated (Michaelowa and Purohit, 2007; Schneider, 2007; Haya, 2009), so it remains unclear whether GEF and CDM have reduced more GHG emissions via RE projects. Given that reported GHG emissions reductions may not be congruent with actual GHG emissions reductions, this thesis will avoid using official data on GHG emissions reductions for analyzing effectiveness; the only exception is chapter 7 where project-level GHG data is used.

Figure 5: Reported GHG emissions reductions by mechanism and project type (2008-2010, average)



Sources: GEF Data from Stadelmann (2009), which is based on numbers in the official GEF documents (GEF, 2011a). Only directly measurable reductions ("direct reductions") are included. The GEF itself also estimates indirect reductions through e.g. capacity building; CDM Effectiveness in reducing GHG emissions is based on data for issued credits from URC (2011). In the effectiveness numbers, we neglect that the CDM as offset mechanism is meant to help industrialized countries complying with their targets, so some of the GHG emissions reductions may actually replace reductions in industrialized countries; MLF numbers from UNEP (2012). The lower estimate of effectiveness only includes projects reducing production of ozone-depleting substances, while the higher also includes projects reducing consumption.

2.2.3 *Academic literature on climate finance*

Finance for climate change mitigation has been studied from very different angles (see Tatrallyay and Stadelmann, 2012), e.g. with regards to its sources (Harmeling et al., 2009; UN, 2010; Springmann, 2013), the amounts required for fair burden sharing (Dellink et al., 2009), its governance architecture (Biermann, 1997; Ballesteros et al., 2010; Müller et al., 2010), the systems for reporting financial flows (Porter et al., 2008; Tirpak et al., 2010; Michaelowa and Michaelowa, 2011a), its contribution to sustainable development (Olsen, 2007; Sutter and Parreno, 2007; Alexeew et al., 2010; Zerriffi and Wilson, 2010), its geographical distribution (Hultman et al., 2009; Castro and Michaelowa, 2010), its contribution to technology transfer (Haites et al., 2006; Schneider et al., 2008; Seres et al., 2009), private companies' perceptions of the CDM (Hultman et al., 2012) and how climate finance should be evaluated (Mee et al., 2008; Donner et al., 2011). To date the most frequently examined issue is the effectiveness of climate finance in reducing GHG emissions (see e.g. Michaelowa et al., 2003; Hepburn, 2009; Schneider, 2009b; Schneider et al., 2010; Zerriffi and Wilson, 2010; Grubb et al., 2011).

2.3 Summary on international climate policy and finance

This chapter has shown that international climate finance has been a key pillar of international climate policy since its beginnings. Already before Rio 1992, developing countries substantially pushed for including "new and additional" financial support in the UN Framework Convention on Climate Change (UNFCCC).

The 1990s were dominated by discussions on the shaping of the Global Environment Facility (GEF) as operational entity of the UNFCCC's financial mechanism, while actual public climate finance flows to developing countries were mainly occurring through other channels. In the 2000s, the CDM as market-based mechanism under the Kyoto Protocol emerged, and even overtook public finance as main international climate finance flow in the years 2006 and 2007. In the years since 2008, new CDM contracts substantially decreased due to the economic downturn and the lack of ambitious post-2012 emission targets. In the same time, reported public climate finance saw a substantial increase, related to promises made at the Copenhagen summit in 2009 but also to increased pressure to report climate finance.

While an overview of US dollars spent for international climate finance is easily possible, this is more difficult in the case of GHG reductions. Only the CDM reports detailed and verified GHG data, while among public finance channels, just GEF and the Multilateral Fund (MLF) under the Montreal Protocol provide some GHG estimates. According to this scarce data, GEF and MLF have been similarly effective than CDM in reducing GHG emissions in the years 2008-2010, while CDM has been much more effective from 2011 on. In sectoral terms, the CDM and the MLF have reduced industrial GHG (e.g. HFC) emissions very effectively, while the GEF mainly excelled in promoting energy efficiency. In case of renewable energies (RE), CDM and GEF have been similar effective according to official reports but data is hardly reliable. Given this similar effectiveness, the lack of reliable data and the substantial role of RE in low-carbon transformation pathways, a closer examination of CDM and GEF effectiveness in promoting RE seems to be warranted.

The academic literature has examined several issues related to international climate finance, particularly the question whether it contributes to sustainable development. However, the effectiveness in reducing GHG remains the core question. As this will also be the focus of this study, the literature on climate finance effectiveness is considered in detail in the next chapter, in order to identify the most important research gaps.

3 Effectiveness of climate finance: definition, literature and research gaps

In this chapter, the literature on the effectiveness of international climate finance is reviewed and research gaps are identified. As background, the term "effectiveness" and its measurement is more precisely defined, followed by official data on different effectiveness measures. Then the common determinants of climate finance effectiveness, as reported in the literature, are reviewed. The main determinants serve as starting point for a more profound literature review that results in the identification of four research gaps and sub-research questions.

3.1 Definition, measurement and official data on effectiveness

3.1.1 Definition of effectiveness

Gupta et al. (2007: 751) have defined environmental effectiveness as "the extent to which a policy meets its intended environmental objective or realizes positive environmental outcomes". In case of climate change mitigation policy, the intended environmental outcome is the stabilization of greenhouse gas concentrations in the atmosphere at a level that prevents dangerous anthropogenic interference with the climate system (UNFCCC, 1992). Given the substantial gap between current (emission reduction and finance) pledges and a climate policy limiting global warming below 2 degrees (World Bank, 2009; Roberts et al., 2010b; Rogelj et al., 2010; Olbrisch et al., 2011), any GHG emission reduction achieved by international climate finance can be seen as contributing to environmental effectiveness. Therefore, *we define effectiveness of international climate change mitigation finance as the ultimately desired environmental effect of climate policy, which is the reduction of GHG emissions, measured in tonnes of CO_2-equivalent.* All reductions of GHG emissions other than CO_2 are transformed to CO_2-equivalents using 100-year Global Warming Potentials (GWP), see Solomon et al. (2007).

Our definition of effectiveness has two important implications. First, our definition of effectiveness focuses on the ultimate *policy outcome* – the actual effects of a policy in terms of environmental goal achievement – and not the policy output – the types and amount of policies and institutional arrangements adopted (for this distinction, see e.g. Hollifield, 1986; Holzinger and Knill, 2005; Bättig and Bernauer, 2009). Under this definition of effectiveness, we are not interested in policy outputs, such as enhanced capacity or regulatory changes (see Eberhard et al., 2004 for the case of the GEF), unless they improve the ultimate policy outcome, GHG emissions reductions.

Second, we only focus on the primary goal of climate change mitigation policy, the reduction of GHG emissions, while neglecting other environmental, social and economic benefits (see Barker et al., 2007). This focus is purely analytical and is not necessarily congruent with the political intentions: apart from reducing GHG emissions the CDM also has the goal to support sustainable development according to the Kyoto Protocol (Olsen, 2007; Sutter and Parreno, 2007), and developing countries have repeatedly tried to re-focus public climate finance, including GEF finding, on development benefits (Fairman, 1996; Najam, 2005). The focus on GHG emissions reductions as desired effect of climate change mitigation finance will, therefore, limit the interpretation of the research findings: the results will only refer to effectiveness in reducing GHG emissions but not to other potential goals of climate finance, such as sustainable development benefits or political interests of industrialized countries (e.g. technology exports, improving bilateral relations). Therefore, some projects or programs may be judged ineffective by this study, as they are not reducing CO_2, while they are actually judged as effective by the program managers or contributors, as development or other benefits are realized. To give a simple example, a project reducing industrial gases like HFC may be very effective in reducing GHG emissions, so it will be judged effective by this study, while projects with low GHG reductions but high development benefits, such as small-scale RE plants (see Sutter and Parreno, 2007), will be judged as rather ineffective by this study.

3.1.2 Output and output-input measures of effectiveness

Effectiveness itself is a pure output measure (GHG emissions reductions), but we may also be interested in how much effect or output (GHG emission reductions) is achieved per input unit (see Table 1). There are two output-input measures, which are of interest: effectiveness per unit of climate finance and cost-effectiveness – both measured in tCO_2eq per USD. Effectiveness per unit of climate finance is simply the amount of GHG emissions reduced per unit of public finance or carbon market payments. Cost-effectiveness is a different measure, as it looks at the effectiveness in relation to economic costs of climate change mitigation.

In case of public climate finance, such as in case of GEF, the two output-input measures can be the same, as the amount of climate finance is supposed to be equal to the economic costs of climate change mitigation. In case of carbon markets, the amount of climate finance is different to the economic costs, as climate finance is dependent on the carbon market price, while the costs depend on the specific mitigation measure, so effectiveness per unit of climate finance and cost-effectiveness are not the same. While this study focuses on effectiveness in reducing GHG emissions overall, we will also consider cost-effectiveness and effectiveness per unit of climate finance, in cases where projects or programs are compared (chapters 5 and 7).

Table 1: Output and output-input measurement of effectiveness

Measure	Type	Definition (in this study)	Unit
Effectiveness	Output	GHG emissions reductions achieved	tCO_2eq
Effectiveness per unit of climate finance	Output/Input	GHG emissions reductions per unit of climate finance	tCO_2eq/USD
Cost- Effectiveness	Output/Input	GHG emissions reductions per unit of economic costs	tCO_2eq/USD

3.1.3 Reported effectiveness

Figure 4 has already provided data on the pure output measure of effectiveness, the reduction of GHG emissions. According to this figure, CDM, GEF and the MLF have been similarly effective per year in the period 2008-2010, while data on effectiveness of other ODA flows is missing. In 2011, CDM became clearly the most effective channel, when credits equivalent to 320 $MtCO_2eq$ were issued (URC, 2012).

Table 2 now adds the output-input measures: claimed effectiveness per unit of climate finance and reported cost-effectiveness. We focus on CDM and GEF here, as they are the only climate finance institutions that provide enough information for estimating output-input measures of effectiveness.

Table 2 shows that in terms of reported effectiveness per unit of climate finance, GEF reports to be at least five times more effective than our estimations for CDM effectiveness per unit of climate finance. The main explanation is that public climate finance pays just the costs of climate change mitigation projects, while CDM funding is dependent on a market price that is often higher than the costs of emission reductions (Müller 2007). It has to be noted that the CDM figures for "effectiveness per USD of funding", are actually not CDM numbers but estimations based on effectiveness claimed by the CDM (each credit represents 1 tCO_2eq) and a market price assumption (10 USD per credit, see footnote in Figure 4 for details on the calculation). We assume here the same CDM credit price for all projects but in fact, some project types like wind energy may receive higher market prices (Wu and Sheng, 2008). Therefore, the 0.1 tCO_2eq/USD figure is just a proxy for effectiveness per unit of climate finance, and may actually differ per type of project, so numbers are set in parentheses.

In terms of cost-effectiveness, so GHG emissions reductions per economic costs, numbers were calculated using information in several GEF and CDM project documents. Using this project document data, CDM projects are on average slightly more cost-effective than GEF projects.

Table 2: Estimated climate finance (in 2009 USD) and reported effectiveness by mechanism and project type (2008-2010)

		Climate finance flows (in 2009 USD million)		Reported effectiveness	Reported effectiveness per unit of climate finance	Cost-effectiveness estimated by author	Years considered
		USD M per year	%	M tCO_2eq per year	tCO_2eq per USD	tCO_2eq per USD	
CDM[1]	Total	1312	100%	131	[~0.1]	0.65	2008-2010
	Industrial gases	978	75%	98	[~0.1]	2.22	2008-2010
	Methane	71	5%	7	[~0.1]	0.47	2008-2010
	Renewable energy	189	14%	19	[~0.1]	0.15	2008-2010
	Energy efficiency	53	4%	5	[~0.1]	3.23	2008-2010
	Transport	0	0%	0	[~0.1]	n/a	2008-2010
	Forestry	0	0%	0	[~0.1]	n/a	2008-2010
	Other	22	2%	2	[~0.1]	n/a	2008-2010
GEF[2]	Total	164	100%	98	0.60	0.60	2008-2010
	Industrial gases	0	0%	0	1.18	1.18	2008-2010
	Methane	1	1%	1	0.39	0.39	2008-2010
	Renewable energy	62	38%	15	0.25	0.25	2008-2010
	Energy efficiency	48	29%	77	1.61	1.61	2008-2010
	Transport	11	7%	2	0.19	0.19	2008-2010
	Forestry	0	0%	0	n/a	n/a	2008-2010
	Other (transport)	41	25%	3	0.07	0.07	2008-2010

[1] Effectiveness equals issued credits in tCO_2eq per year (URC 2011). Cost-effectiveness is calculated as the inverse of median abatement costs per project type, as calculated by Castro (2010). Effectiveness per USD of funding is the inverse of the expected primary CDM credit price. This primary credit price is estimated to be 10 USD per tonne of CO_2, based on primary credit prices reported by GIZ (2011) and the World Bank carbon market reports (Lecocq and Capoor, 2005; Capoor and Ambrosi, 2006, 2007, 2008, 2009, 2010); the average of the years 2004-2009 is taken. (In fact, this credit price may differ per type of project). In the effectiveness numbers, we neglect that the CDM as offset mechanism is meant to help industrialized countries complying with their targets, so some of the GHG emissions reductions may actually replace reductions in industrialized countries. CDM funding is calculated as issued credits multiplied by an estimated credit price of 10 USD per tonne of CO_2.

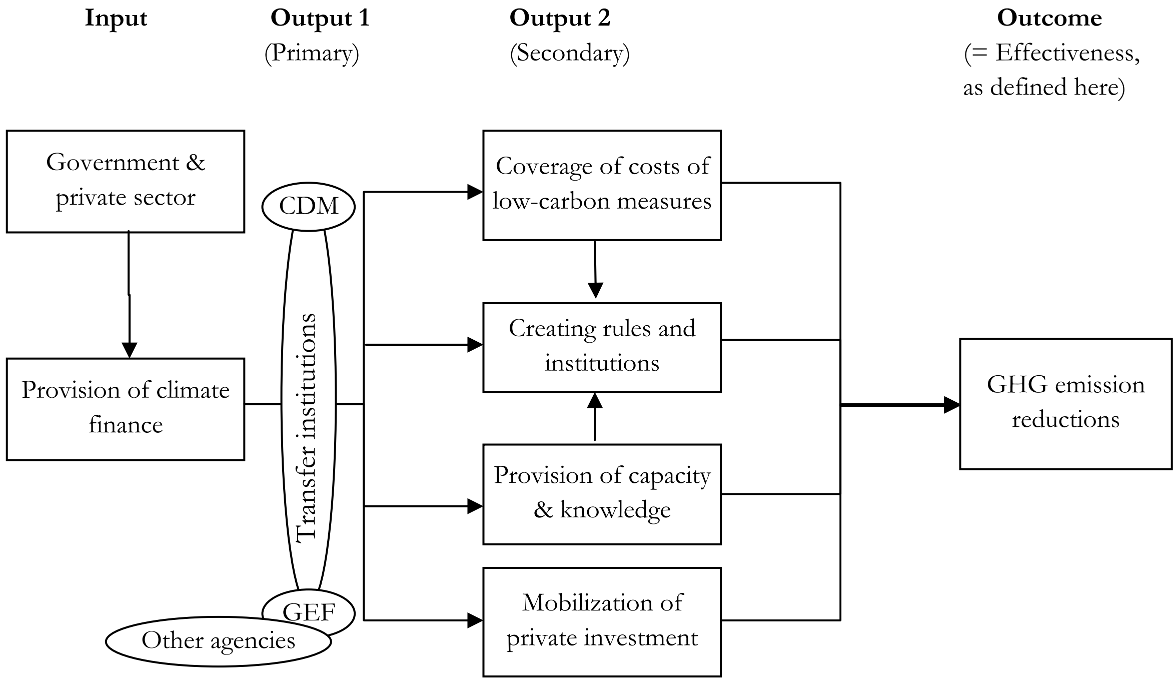
[2] Data from Stadelmann (2009) based on numbers in the official GEF documents (GEF, 2011a). Only directly measurable reductions ("direct reductions") are included. The GEF itself also estimates indirect reductions through e.g. capacity building. The transaction costs (agency fees, GEF secretariat) are not included here.

3.2 Potential determinants of effectiveness according to the literature

Figure 6 shows the different components of the effectiveness of environmental regimes according to Underdal (2002), applied to the case of international climate finance. Our measure for effectiveness, the reduction of GHG emissions, can be considered the outcome of the regime, as it constitutes the desired "change in behaviour". For simplicity, the figure omits the ultimate impact of a regime, the biophysical change (Underdal, 2002), which is the change in GHG concentrations in the atmosphere in our case. Furthermore, we add the input level, which is a common element of causal chains (see Earl et al., 2001).

Figure 6 also helps to depict potential determinants of effectiveness. First, effectiveness in reducing GHG emissions may depend on financial inputs (see Keohane, 1996 for environmental aid in general), such as public finance or carbon credit purchases. Second, effectiveness of climate finance will also depend on the intermediate outputs of climate finance. Outputs of international agreements are established norms, principles, and rules (Underdal, 2002), so e.g. the "institutional arrangements" governing the transfer of financial resources (Keohane, 1996), such as CDM and GEF. As these institutions do not reduce emissions themselves but via specific tools, CDM and GEF are considered as primary output of climate finance and we add secondary outputs to the causal chain. Such secondary outputs are e.g. the coverage of mitigation costs for low-carbon technologies, which is often seen as key for climate change mitigation by economists (e.g. Criqui et al., 1999; Klepper and Peterson, 2006; Kuik et al., 2009; Olbrisch et al., 2011), the creation of institutions like national policies as emphasized by political scientists (see e.g. Haas, 1989; Keohane et al., 1993; Underdal, 1998), the creation of capacity and knowledge, as studied by political scientists (Krasner, 1982b; Haas, 1992; Haas et al., 1993; Mitchell, 1998; Stokke et al., 1999; Breitmeier et al., 2011) and science and technology studies (Lundvall, 1992; Malerba, 2002; Hekkert et al., 2007), and finally the mobilization of private finance, which is a growing concern of politicians and funding agencies (EU, 2011; G20, 2011) and often considered as pre-requirement for successful climate policy (Gentry and Esty, 1997; Lile et al., 1998; Zhang and Maruyama, 2001; Bowen, 2011).

Figure 6: Financial input and intermediary outputs as determinants of effectiveness of climate finance



In the following, the literature is reviewed for the identified determinants of climate finance effectiveness: finance availability, cost coverage for low-carbon measures, the creation of institutions, the provision of capacity and knowledge, and the mobilization of private finance. In each part, a literature gap and a research question is identified.

3.3 Literature gaps

3.3.1 Provision of climate finance

Provision of climate finance will both depend on carbon credit purchases and public finance. The demand for carbon credits from developing countries has been studied thoroughly. Purchases under the Kyoto Protocol depend on the difference between emission paths and GHG emission targets of industrialized countries, and the extent to which these countries are closing the difference with carbon credits from developing countries (Anger et al., 2007). Regarding the emission-target difference, Bhatti et al. (2010) find that EU members, richer countries, the ones with high GHG emissions, and high projected growth rate have committed to the strictest Kyoto targets. In contrast, former East-Bloc countries received more allowances than projected emissions (so called "hot-air"), which was projected to reduce the demand for CDM credits (Jotzo and Michaelowa, 2002). Until now, "hot-air" allowances have only been bought by Japan and EU countries for the non-ETS sector, while Russia has not yet sold any allowances (Aldrich and Koerner, 2012). Further limitations for CDM demand were the non-ratification of the Kyoto Protocol by the USA and the possibility to account for carbon sinks (Jotzo and Michaelowa, 2002). Apart from the Kyoto targets, the commitments of individual countries have also been studied for the burden sharing within the EU (Oberthür and Ott, 1999; Michaelowa and Betz, 2001) and the Copenhagen pledges (Brechet et al., 2010). Regarding the flexibility to use credits from developing countries for compliance, the EU's attempt to limit CDM imports internationally may have been linked to low domestic abatement costs compared to the US and Japan (Zhang, 2001). While CDM imports were not restricted globally, the EU decided to use CDM credits for no more than 50% of their emission reduction obligations under the Kyoto Protocol. Flues (2012) studied the allocation of CDM import quota within the EU, and found that both environmental and business interests are influential. Apart from governmental decisions, CDM purchases also depend on business strategies to use carbon credits (see Pinske, 2006; Pinske and Kolk, 2007).

Less is known on the side of public climate finance. As studies on public climate finance provision are rare, the literature on provision of ODA may be enlightening. Support for ODA provision has been found to be more likely if leftist and not conservative parties are in power (Imbeau, 1989; Therien and Noel, 2000; Milner and Tingley, 2010; Tingley, 2010), if donor governments or parliamentarians have specific economic interest (Imbeau, 1989; Milner and Tingley, 2010), if pro-ODA interest groups are strong (Milner and Tingley, 2010) and if donors perceive that recipients need assistance (Imbeau, 1989). In case of environmental ODA, Roberts et al. (2009) observe an increased share of green aid in the 1990s, probably related to NGO protests in the 1980s. Hicks et al. (2008) argue that the change towards a higher share of environmental aid was triggered by governmental change (Germany, USA), lobbying of NGOs and other interest groups (Germany, UK, and Japan), commercial and security interests (USA) and international pressure (UK, USA, Japan). In a cross-country comparison they found that "dirty" aid is low in countries with high wealth and strong environmental lobby groups, while these determinants do not significantly increase "green" (environmental) aid. Therefore, the determinants of ODA, including environmental projects, are quite well known.

In contrast, the provision of climate-related public finance has only been examined by three studies, one on adaptation finance (Michaelowa and Michaelowa, 2012) and two on mitigation finance (Michaelowa and Michaelowa, 2011b; Halimanjaya and Papyrakis, 2012). These studies find rather different patterns than for ODA: the oil price (Michaelowa and Michaelowa, 2011b) and environmental expenditures in general (Halimanjaya and Papyrakis, 2012)[13] have driven finance with mitigation benefits, while the perceived need of assistance (natural catastrophes) has driven adaptation aid. According to Michaelowa and Michaelowa (2011b; 2012), international climate agreements had some influence. In case of mitigation, finance increased after the Rio conference and decreased after Kyoto, while in case of adaptation, finance increased after Kyoto.

Most of the just mentioned studies use econometric approaches to analyze the determinants of ODA and climate finance provision. Such studies have the advantage that hypotheses can quantitatively be tested. However, these studies also rely on the availability of quantitative data, which are missing when we are interested in the impact of specific wordings in international decision texts. In such cases, a qualitative analysis of the concrete decision texts and their meaning seems to be warranted. For example, by looking at concrete UN climate decision texts, we may explain the econometric finding of Michaelowa and Michaelowa (2011b; 2012) that mitigation funding increased in the 1990s and adaptation funding increased in the 2000s: the UNFCCC in 1992 clearly focused on mitigation (see e.g. Ciplet et al., 2013, Khan & Roberts, forthcoming) and asked for the provision of "new and additional" financial resources, so an increase in mitigation but not adaptation finance seems to be coherent with the decision. Similar insights can be found when analyzing the decision within the Kyoto Protocol: no new public finance pledges for mitigation were specified but the CDM was created, partly a response to the finance demands from developing countries (see chapter 2.2.1), which led to substantial non-public finance to developing countries, and the impression that public mitigation finance was less needed. Therefore, the decrease of public mitigation finance after Kyoto seems at least partly explainable by qualitative analysis of UN decision texts. Finally, the negotiations on the implementation of Kyoto resulted in two new funds that mainly supported adaptation (UNFCCC, 2001), so an increase of adaptation funding in the 2000s seems consistent with UNFCCC decision texts. Finally, the Copenhagen decision text in 2009 included wording on additional funding and a "balance" between mitigation and adaptation, which led to substantial climate rise in climate finance (see Figure 2) and the provision of 50% funding allocation to adaptation by some countries (Stadelmann et al. 2012)[14].

Such qualitative analysis on decision texts may also help to explain the meaning of the term "new and additional" finance, which is repeatedly occurring in UN decision text, and which may have an influence on the level of finance provided. While the term "new and additional" was originally introduced by developing countries to avoid re-redirection of development aid resources (Benedick, 1991; Bodansky, 2001; Chasek et al., 2010), the term was never clearly defined. In the Marrakesh declarations, "new and additional" seems not only to refer to funds beyond development assistance but also beyond existing public climate finance, so it could mean that climate finance has to be increased. In the Copenhagen Accord, there was again no clear definition of "new and additional" and several interpretations have been proposed both by developing and developed countries (Brown et al., 2010; UNFCCC, 2011c). The only general agreement seems to be that "new and additional" refers to an increase beyond a certain level, which can be called the "baseline" level of finance. One of the main tensions in the definition for "new and additional" is that the "baseline" may both refer to a specific level of development aid or climate

[13] The results of Halimanjaya and Papyrakis (2012) remain dubious as, according to their models, high GDP per capita and left governments tend to decrease the provision of public climate finance, which is opposite to theoretical expectations. These non-convincing results may be related to the analysis of officially reported climate finance. Therefore, their findings may rather relate to *reported* and not necessarily to *provided* climate finance.

[14] Overall the share of adaptation was below the 50%, so not all countries understood the word balance as half-half allocation to mitigation and adaptation (Stadelmann et al. 2012).

finance. Given the goal of developing countries to avoid redirection of aid flows and the political need to increase climate finance to limit global warming to 2-degrees, the first research gap and question is;

How would the term "new and additional" have to be defined to enable an actual increase of climate finance without redirection of development aid? (Research question 1)

3.3.2 Covering costs of low-carbon measures

From an economic perspective on climate policy, the most important strategy for climate finance for having an effect on GHG emissions is to give a financial incentive to reduce GHG emissions. Most economists (e.g. Pearce, 1991; Baranzini et al., 2000; Nordhaus, 2006; Stern, 2007) agree that the most effective and efficient policy to enable low-carbon measures is to set a price on GHG emissions, e.g. via carbon taxes or an ETS. A price on pollution should be effective, as it provides a direct economic incentive, and it should be cost-effective, as only measures with mitigation costs below the market price are undertaken, which has been both theoretically discussed (Baumol and Oates, 1971, 1988) and empirically observed (Stavins, 2003). The more GHG emissions are covered by a uniform carbon price, the lower the costs of reaching a specific GHG reduction goal. This has been analyzed both for different GHG gases (Bernard et al., 2006) and for emissions from several countries (Criqui et al., 1999; Zhang, 2001).

The view that a uniform carbon price for a wide geographic area should reduce costs of climate policy is one of the key logics behind the CDM: the extension of the carbon market to developing countries should reduce compliance costs for industrialized countries (Criqui et al., 1999; Zhang, 2001). If the carbon price is fully transmitted by the CDM to all individuals in developing countries, then the lowest-cost mitigation options should be undertaken, and the CDM should clearly be more cost-effective than public finance channels such as the GEF, under which political considerations are important and hardly any incentive to choose the least cost solutions exist (Heller and Shukla, 2003). So at first sight, it seems obvious that under the CDM less financial means are needed to reduce one unit of GHG emissions than under public finance channels such as the GEF.

However, there are the least five reasons why it is not clear whether the CDM can generate more GHG emissions reductions per dollar of funding than public finance. Four of these five reasons are related to the question whether the assumption of a perfect market with no political interference and no transaction cost hold under the CDM, while the fifth reason is the occurrence of rents.

The first reason of a non-perfect CDM market is the occurrence of administrative transaction costs (Michaelowa et al., 2003; Michaelowa and Jotzo, 2005). Projects have to follow a complicated process to receive CDM credits, including host country approval, validation of project documents, registration, monitoring of GHG emission reductions, verification and issuance of credits by the CDM EB. These verification costs are particularly high compared to carbon taxes and emission trading, as not only the actual level of GHG emissions has to be verified, but also the counterfactual level of "baseline" emissions, so the business-as-usual (BAU) emissions without CDM intervention. Further costs occur for finding credit buyers, contract negotiation and enforcements. If all these administrative transaction costs are summed up, small-scale projects are not attractive any more under the CDM, while larger projects can easily cover these costs (Michaelowa et al., 2003; Michaelowa and Jotzo, 2005). While important steps have been undertaken to reduce administrative costs of small-scale projects, e.g. simplified methodologies and rules, bundling of projects and Programmes of Activities (PoAs), substantial transaction costs remain. Still, administrative transaction costs for an average CDM project, as estimated by Michaelowa et al. (2003), are not higher than in case of the GEF, where implementing agencies charge a 10% administrative fee (GEF, 2011b).

The second reason for a non-perfect market is the political design of the CDM (see chapter 2.2.1) that has led to the exclusion of some mitigation opportunities from the market. First of all, some mitigation projects are excluded by definition, e.g. the certification of reduced deforestation (Santilli et al., 2005) or nuclear power plants (see decision 16/CP.7, UNFCCC, 2001). However, public climate finance excludes even more project types, such as industrial gases, so CDM should still be comparatively cost-effective. More importantly, CDM credits are not issued to projects representing policies (UNFCCC, 2005c), so regulatory policies (including carbon taxes and ETS) are excluded. This is a potential advantage of public finance (e.g. GEF) that also supports the setup of policies.

The third reason why the CDM may not form a perfect market is missing information at the level of investors. It has widely been studied that many mitigation projects, particularly in the energy efficiency field, would be profitable but they are not undertaken because companies or households miss information on these opportunities (Jaffe and Stavins, 1994; Painuly, 2001; Sorrell et al., 2004). In case of asymmetric information (e.g. between landlords and tenants) or a wide spread information problem (e.g. cost-saving light bulbs) a market failure may exist, and government interventions, e.g. via information campaigns, standards or economic incentives may be warranted (Jaffe and Stavins, 1994). In such cases, public finance may be more cost-effective and effective than a project-based market mechanism as it can support public policies, such as energy efficiency standards, and finance "soft" measures such as information campaigns. It has to be noted that there are doubts on whether "soft" measures are always efficient (see e.g. Pearce, 1991; Stavins, 2003).

The fourth reason for a non-perfect CDM market – may be the most important one – is the problem of asymmetric information between the project investors and the persons approving the crediting. If projects are business-as-usual (BAU), i.e. they would have been implemented even without CDM support, then CDM approval is not warranted from an effectiveness point of view. However, the CDM EB and verifiers may not be able to detect the relevant information so these projects still receive CDM approval. Approval of such "business-as-usual" (by some called non-additional"[15]) projects has been detected in several case studies (Michaelowa and Purohit, 2007; Haya, 2009; Schneider, 2009b). Some studies have even concluded that a whole range of CDM projects, including most RE projects, may have happened without the CDM (Schneider, 2007; Haya, 2009). Approval of BAU projects would substantially reduce effectiveness and cost-effectiveness of the CDM[16], given that renewable energies form the majority of registered projects. While the CDM has substantially strengthened the project assessment in the last years, rejecting several projects and making it very difficult for projects to be approved without showing a financial investment barrier[17] (Michaelowa, 2009), there may still be "business-as-usual" projects registered, particularly as small-scale energy projects do not have to prove additionality anymore (UNFCCC, 2011f). Clearly, there is a trade-off for the regulators: introducing

[15] The term "additional" is interpreted differently in the literature. According to the official CDM definition, a CDM project is additional if "anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the registered CDM project activity (3/CMP.1, Annex, paragraph 43)." This could simply mean that the project must reduce emissions but it is more often understood that a CDM project should not be financially viable without CDM support (Greiner and Michaelowa, 2003) or that it should not have happened without CDM support (Schneider, 2009b).

[16] If BAU projects are financially attractive (e.g. in case of energy efficiency), then they are very *cost-effective* projects *on their own*, as they do not cost anything. However, *supporting* these financially attractive BAU projects with climate finance (e.g. CDM credit payments) is *not cost-effective*, as the effect in terms of GHG reductions is zero, while transaction costs for raising and spending climate finance occur.

[17] A financial investment barrier can be shown by either proving that the project's Internal Rate of Return (IRR) is lower than the returns required on the market (benchmark IRR) or by showing that high-carbon investment alternatives have better returns.

stricter rules may reduce the number of “bad” projects being approved (less false positives) but it may also lead to “good” projects being rejected (more false negatives), see Trexler et al. (2006). Furthermore, in-depth assessment of projects will also increase the administrative transaction costs.

The fifth and last reason, why the CDM may be less effective per USD of funding is not related to economic costs but related to rents that accrue to the sellers of CDM credits: while buyers pay the market price for CDM credits, the actual cost of emission reductions is in many cases much lower. This leads to substantial rents (or “producer surpluses”) for credit sellers (Müller, 2007). Such producer rents do not increase economic costs as they are simply representing economic value transferred from buyers to sellers. However, from a climate policy perspective, rents may still represent an ineffective use of climate finance. Some scholars (Fein et al., 2010; McNish, 2010) have argued that a climate fund that avoids rents by paying only the incremental costs of projects, such as the GEF or the MLF (Biermann, 1997) may be more effective per USD of funding. As counter-argument, Hepburn (2009) argues that rents attract investors and may enhance long-term effectiveness. Empirically, it has not been studied whether the advantages of the CDM compared to public funding (dynamic incentives for reductions, openness to different project types) has outweighed the rent-losses in terms of effectiveness per USD of funding. However, there are clearly cases like HFC-reducing projects where enormous rents have led to reduced effectiveness, as the rents proved to be a perverse incentive to artificially inflate production in order to claim more CDM credits (Schneider, 2011).

All of these five theoretical factors why the CDM may not reduce GHG emissions for the lowest amount of funding – administrative costs, political design, missing information, promotion of business-as-usual projects due to asymmetric information, and rents to credit sellers – have been empirically examined: substantial transaction costs occur for both GEF and CDM (Michaelowa et al., 2003; Michaelowa and Jotzo, 2005), the forestry sector was largely excluded from both CDM and GEF during their political design, and the CDM has also not fully addressed the energy efficiency potential due to administrative costs and missing information (Grubb et al., 2011; Castro, 2012; Tatrallyay and Stadelmann, 2012). Promotion of business-as-usual projects has been assessed by several case studies (Michaelowa and Purohit, 2007; Schneider, 2007; Haya, 2009; Schneider, 2009b), and the existence of substantial rents have been detected particularly in case of industrial gases (Müller, 2007; Stadelmann et al., 2011a).

Even when all theoretical factors have been empirically analyzed, there is an important research gap in relation to the promotion of BAU projects due to asymmetric information: it has neither been examined with independent nor with macro level data. First, empirical studies have relied on data from CDM project documents, which are written by project developers, and will, therefore, not fully reveal how substantially the promotion of BAU projects affects effectiveness of the CDM. Apart from this problem of non-independent data, existing research (Michaelowa and Purohit, 2007; Schneider, 2007; Haya, 2009; Schneider, 2009b) is restricted to the analysis of *project effectiveness (micro level)*, while no study is known that has assessed how the support for business-as-usual projects affects the *aggregate effectiveness (macro level)*[18] of the CDM and, whether public finance has performed better in this regard.

Such a macro level analysis using independent data seems to be particularly relevant for the case of RE projects because of at least 4 reasons: First, RE is a key project type for both CDM and GEF, both with regards to funding and effectiveness (see Table 2). Second, many CDM renewable energy project have been found to be business-as-usual (Michaelowa and Purohit, 2007; Schneider, 2007; Haya, 2009). Third, RE technologies are seen as key technologies in low-carbon transformation paths (Krey and Clarke, 2011). Finally, analyzing the effectiveness of the CDM in reducing CO_2 via renewable energies

[18] See Keohane (1996) for the distinction between project and aggregate effectiveness in case of environmental aid.

from a macro level may not only enhance the understanding of business-as-usual projects but also contribute to close a gap in another strand of literature: while many studies have analyzed the determinants of RE diffusion in industrialized countries (e.g. Carley, 2009; Marques et al., 2010; Marques et al., 2011; Popp et al., 2011), only two have looked at the determinants in developing countries (Sadorsky, 2009; Brunnschweiler, 2010), and both of them have neglected international climate finance as potential driver. Therefore, the second research gap and question is;

How effective has the CDM been in reducing GHG emissions via renewable energy diffusion, and how effective has public finance been in comparison? (Research question 2)

3.3.3 Creation of institutions and capacity

Many social scientists – particularly in the area of international relations and "science and technology studies" – have stressed the role of institutions and the capacity of actors in effective international responses to environmental problems. *Institutions* "are rules of the game in a society or, more formally, are humanly devised constraints that shape human interaction (North, 1990: 3)." Organizations can be seen as special institutions with clear boundaries, sovereignty rules and chains of command (Hodgson, 2006).

Institutions are relevant for international climate finance in at least two ways: climate finance is governed by transfer institutions, and it creates institutions, such as national policies itself. First of all, climate finance is governed by international institutions, such as the GEF and CDM. Such "financial transfer institutions" are "sets of rules […] established to govern a flow of funds from richer to poorer countries to achieve specific environmental purposes (Keohane, 1996: 5)". These institutional arrangements will substantially determine the effectiveness of financial transfers (Keohane, 1996): e.g. the distributional struggles during the set-up has clearly undermined the effectiveness of GEF (Fairman, 1996), while institutional costs can also be observed for the AIJ and CDM (Heller, 1999; Michaelowa and Jotzo, 2005).

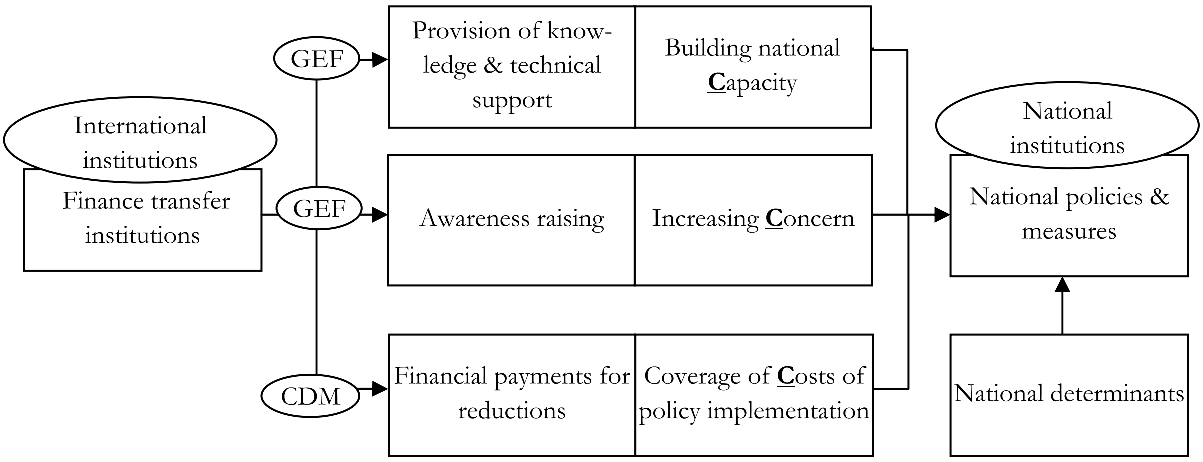
Secondly, and important for effective spending, climate finance transfers may create or support national institutions for climate change mitigation. Among these newly created institutions, *national policies* are particularly relevant for the effectiveness of international environmental regimes (see e.g. Haas, 1989; Keohane et al., 1993; Underdal, 1998). Such national policies, including emission targets in developing countries, are considered to be crucial in the climate regime for achieving the 2 degree limit (Frankel, 2007; Michaelowa, 2007c; Den Elzen and Höhne, 2008). Scholars have not only discussed the set-up of climate-specific policies but also, as a potentially effective strategy, the integration of climate change activities in national development policies (Winkler et al., 2007; Winkler et al., 2008). Developing countries have made clear that their recently pledged mitigation policies and measures are conditional on financial support (UNFCCC, 2008b, 2009b). Therefore, it seems warranted to analyze the impact of climate finance on national policies as key institutions in the climate regime.

Figure 7 shows three channels through which climate finance may induce developing countries to enact national climate policies as key institutions for climate change mitigation. The first two, *capacity* and *concern*, are important determinants for the effectiveness of environmental regimes (Haas et al., 1993)[19].

[19] Haas et al. (1993) mention the "contractual environment", e.g. the negotiation arenas, as further determinant for the effectiveness of environmental regimes but we leave this away here, as – in this chapter – we analyze the use of funding once international negotiations have already decided on the provision of climate finance.

The third channel – *coverage of policy costs* – is actually part of "building capacity" in the concept of Haas et al. (1993) but we are keeping it analytically separate here to clearly distinguish between financial capacity (ability to cover costs) and other capacity (e.g. human and institutional). In the following, we will discuss the theory and existing literature on these three channels.

Figure 7: Channels for international climate finance to induce national policies



The first channel for climate policy to induce national policies is the creation of *capacity* via the provision of knowledge and technical support. With capacity, we do not mean financial capacity here but the technical, legal and administrative capacity to negotiate, elaborate and implement regulations. Such capacity can be provided via transfer of expertise and knowledge within an environmental regime (Haas et al., 1993). Capacity and knowledge may also be relevant for businesses to advance innovative technologies (Lundvall, 1992; Jacobsson and Johnson, 2000; Malerba, 2002; Hekkert and Negro, 2009) but we focus here on the capacity of governments, which are seen as key by scholars (Haas et al., 1993; Keohane, 1996; Underdal, 2002). While capacity and knowledge both influence agenda setting and development of rules and norms at the international level (Haas, 1989; Keohane et al., 1993), they are also key on a national level, e.g. for implementation, or monitoring and verification of compliance (Mitchell, 1998), and for design and implementation of national measures (Haas et al., 1993; Underdal, 2002). Climate finance may improve such national capacity via provision of knowledge and also assistance to elaborate policy programs. Such capacity building is not undertaken by the CDM, the CDM is even partly dependent on capacity building by public finance[20]. In contrast, capacity building for developing countries, including support for policy design, is a core strategy of the GEF (Lindholt, 2005; GEF, 2011c). However, there is a debate on whether such capacity building efforts are effective (Keohane, 1996) and to our knowledge no independent study has ever analyzed the effectiveness of GEF's capacity building for policy design.

A second channel for inducing national policies is to increase governmental *concern* for environmental issues (Keohane, 1996), which is not a strategy of the CDM, while the GEF has raised some awareness via training at the national and sub-national level, e.g. in China (Heggelund et al., 2005). Again, the real impact of this awareness-raising on national policies has never been studied.

[20] Some ODA funding was needed for building host country capacity in least developed countries to facilitate the access to CDM funds (Michaelowa, 2003; Okubo and Michaelowa, 2010).

As third channel to induce national policies, climate finance may *cover costs* of implementing public policies, as recently proposed in the context of feed-in tariffs (Edkins et al., 2009; Deutsche Bank Group, 2010). Such cost coverage is not the core of GEF programs that finance at best the implementation of some pilot installations. Also in case of CDM, cost coverage of policy implementation is officially not foreseen as policies are not credited under single CDM projects (UNFCCC, 2005c). Nevertheless, CDM credit payments may reduce the cost of public policies. If e.g. all renewable energies receive CDM credits, then the governmental subsidies to make renewable energies financially viable can be lowered, and governments may be more willing to adopt policies. However, this potential incentive for policy adoption has only existed since 2005, when the CDM EB made clear that climate-friendly policies adopted after 2001 will not lead to fewer credits (UNFCCC, 2005a). Before this decision, there were fears that the CDM provides a disincentive for national policy adoption as projects enabled by national policies by may be judged "non-additional" (Winkler, 2004). Despite the EB decision of not punishing climate-friendly policies, the application of the rule was not fully clear. In 2009, the EB rejected several wind power plants, arguing that the reduction of the feed-in tariff by Chinese regulators has to be understood as climate-unfriendly policy that has to be punished, while most carbon market players and Chinese regulators still saw the (reduced) feed-in tariff as climate-friendly policy. This case showed that the current CDM rules cannot rule out perverse incentives (He and Morse, 2010). Therefore, the CDM may theoretically both have a positive or negative impact on policy adoption, and empirically the situation is not clear.

Given the research gap on whether GEF's capacity building and awareness raising or CDM's cost-coverage have an impact on national policy adoption, an empirical study seems to be warranted. For several reasons, one of the most interesting sectors in this regard could be the one of renewable energies. First, GEF actively aims at supporting the set-up of RE policies (GEF, 2011c). Secondly, the potential for perverse incentives of the CDM on national policy adoption has so far mainly been discussed with regards to renewable energies (Winkler, 2004; He and Morse, 2010). Thirdly, such a study could also contribute to the literature on the drivers for RE policy adoption that has entirely focused on industrialized countries (Michaelowa, 2004; Jacobsson and Lauber, 2006; Vachon and Menz, 2006; Huang et al., 2007; Matisoff, 2008; Laird and Stefes, 2009; Uba, 2010). Therefore, the third research gap and question is:

Has international climate finance induced developing countries to undertake renewable energy policies? (Research question 3)

3.3.4 Private finance

Another away to make climate finance effective, apart from covering costs of low-carbon technologies, building capacity and creating institutions, may be to mobilize private finance. This way has been recently hailed by public institutions (EU, 2011; G20, 2011) development agencies (Assmann et al., 2011; IFC, 2011) and even some NGOs (Brown and Jacobs, 2011)[21]. Some of these non-academic institutions call for (Assmann et al., 2011) or explore ways (Brown and Jacobs, 2011) on how to increase the ratio between mobilized private investments and mobilizing public finance.

In the academic literature, the mobilization of private investments has not been studied itself but there is some related literature. First of all, many scholars conclude that the private sector will be needed for a large part of investments in low-carbon technologies given the high private share of the overall

[21] The calls clearly focus on the mobilization of private investments, not the mobilization of private donations for GHG emissions reductions (Assmann et al., 2011; Brown and Jacobs, 2011), so we will only refer to private investments in the following.

investment capital (Lile et al., 1998; Zhang and Maruyama, 2001; Schmidt et al., 2008; Brinkman, 2009; Bowen, 2011; Olbrisch et al., 2011). Furthermore, several studies – outside the climate context – have found that the private sector is often more efficient in implementation (Dunkerley, 1995; Estache, 2001; Mueller, 2003; Pattillo, 2006; Hodge and Greve, 2007). Therefore, the academic literature would suggest that private investments will be needed for low-carbon transformation and the private sector should be included in the implementation.

These two findings in the academic literature – need for private investments and efficiency of the private sector in implementation – do not necessarily imply that mobilizing private finance will increase the effectiveness of international climate finance. One general caveat is that climate finance, such as GEF and CDM, already mobilize private investments and include the private sector in implementation (Clémençon, 2006; Zhang, 2006; Ellis et al., 2007), so mobilizing private finance would require an *additional* focus on mobilization of private investments. Therefore, the question is whether an additional focus on private finance can increase effectiveness and/or cost-effectiveness.

In case of the CDM, an *additional* focus on mobilization of private investments is clearly questionable from an cost-effectiveness point of view: currently, the CDM already promotes the projects reducing GHG emissions most cost-effectively, given that the CDM only rewards GHG emissions reductions (by issuing credits per tonne of CO_2 reduced) but not any other benefits[22], so private actors will only invest in projects that reduce GHG emissions for costs lower than the carbon price. If instead, CDM would not reward GHG emissions reductions itself but private investments in low-carbon technologies, this may not lead to the selection of the least-costly projects because of several reasons. First, a substantial part of CDM projects involves public investments[23], so these projects would essentially be excluded. Second, the main goal of private investors (maximizing profits) is not congruent with the political goal of reducing GHG emissions because investors take into account non-carbon returns such as electricity payments (Greiner and Michaelowa, 2003; Matsuhashi et al., 2004; Schneider, 2009b) when deciding in which GHG-reducing project types to invest.

A trade-off between (cost-)effectiveness in reducing GHG emissions and mobilizing private finance should also exist in case of GEF projects. While at first sight a strategic GEF focus on the private sector seems to be warranted, given that GEF has often been criticized for not including the private sector enough (Streck, 2001; Lindholt, 2005; Clémençon, 2006), the mobilization of the private sector may also be achieved by a strategy of selecting the projects that are most cost-effective in reducing GHG emissions. This is because such a strategy would require to overcome the most important barriers for private sector access, e.g. the simplification of the complex GEF project approval process (Streck, 2001) and the abolishment of the formula allocating fixed funding amounts to each country (GEF, 2010c).

Summing up, there are theoretical arguments that a focus on private finance mobilization may not be the most cost-effective and effective strategy for climate finance. As this has never analyzed empirically, our fourth sub-question is:

How does a focus on mobilizing private finance influence the cost-effectiveness and effectiveness of climate finance? (Research question 4)

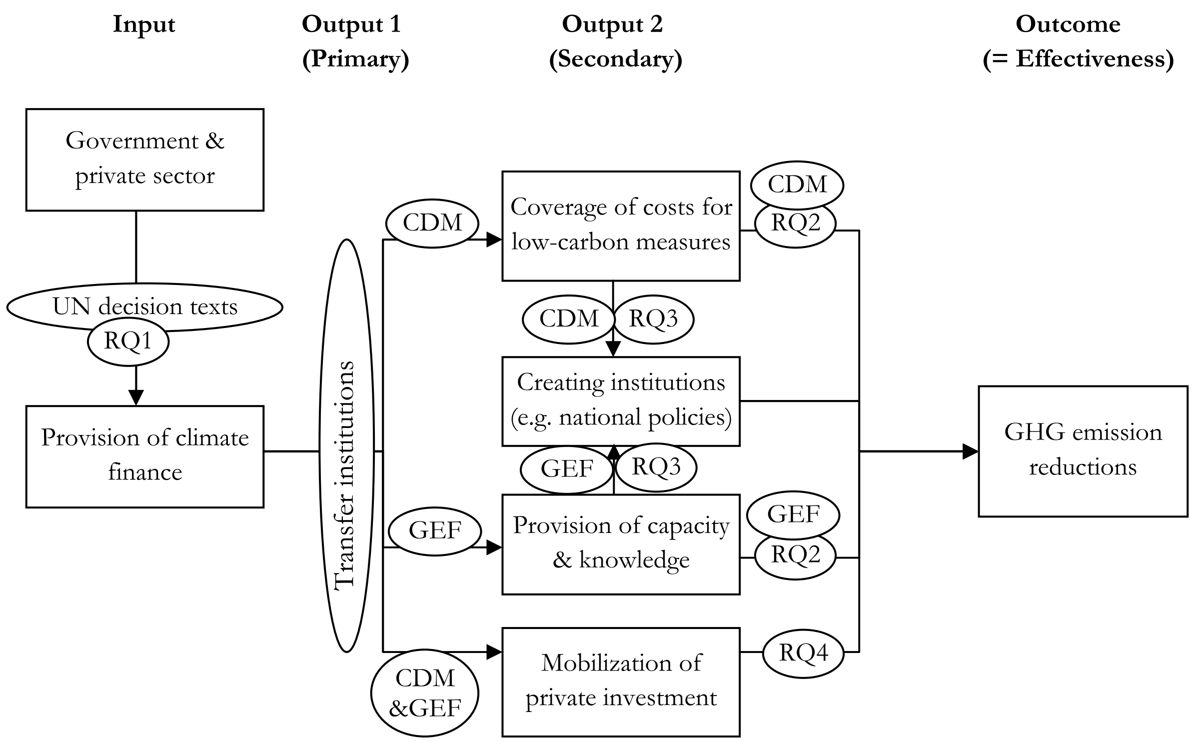
[22] Actually, this focus on GHG reductions has been criticized by some scholars, who argue that, currently, projects with substantial development benefits are not enough promoted (Sutter and Parreno, 2007; Alexeew et al., 2010).

[23] In a sample of 227 CDM projects selected by Castro (2010), 39% of projects involved some public investments, according to our analysis.

3.4 Overview of research questions

Figure 8 provides an on overview on how the four research questions are integrated in our framework of climate finance effectiveness. The first research question (RQ1) addresses the question on how the financial input may be enhanced by specific decisions on the term "new and additional", without leading to a redirection of aid flows. RQ2 addresses the question whether financial inputs covering costs of low-carbon measures via a carbon price (CDM strategy), or rather the financial payments providing capacity and knowledge (GEF strategy) have been more effective in reducing GHG emissions via renewable energies. Then, RQ3 asks whether the CDM strategy (covering costs) or the GEF strategy (providing capacity) have led to adoption of national RE policies, which are seen as key institutions in supporting low-carbon development. As national RE policies are an indirect way of promoting RE and reducing GHG emissions), RQ3 on policy adoption complements RQ2 that looks at the direct effectiveness in reducing GHG emissions via promoting RE. Finally, RQ4 examine whether a focus on mobilization of private finance can enhance cost-effectiveness of climate finance.

Figure 8: Research questions, as embedded in the framework of climate finance effectiveness



3.5 Strategies to answer research questions

For each research question, a different empirical strategy (methods and data) will be applied in the following four chapters.

Chapter 4 analyzes research question 1: *How would the term "new and additional" have to be defined to enable an actual increase of climate finance without redirection of development aid?* In this chapter, different definitions of "new and additional" are examined with regards to the political support they have and the potential implications on effectiveness. This analysis relies on a review of the literature, negotiation documents and other secondary text sources.

Chapter 5 analyzes research question 2: *How effective is the CDM in reducing GHG emissions via renewable energy diffusion and how effective has public finance been in comparison?* This research question will be addressed by, first, theoretically discussing the reasons why CDM and GEF may have an impact and why it may be overestimated, and second, by quantitatively estimating the impact of CDM and GEF on RE diffusion, using panel data models controlling for other determinants of RE diffusion. The dataset is based on direct or transformed secondary sources, and covers more than 20 years and 120 countries. Models for five different RE technologies are estimated.

Chapter 6 analyzes research question 3: *Has international climate finance induced developing countries to undertake renewable energy policies?* This research question will be addressed by, first, theoretically discussing the different variables influencing policy adoption, and, second, estimating the determinants of RE policy adoption in developing countries, using an event-history model on four different RE policies. The policy data set is self-compiled from various secondary sources and covers the last 10 years and more than 160 countries. Climate finance is only one potential determinant of RE policy adoption, so we also test for the influence of other determinants, both domestic and international ones.

Finally, Chapter 7 analyzes research question 4: *How does a focus on mobilizing private finance influence the cost-effectiveness and effectiveness of climate finance?* This question is addressed by both a theoretical analysis how private finance and GHG emissions reductions interact, followed by a two-step empirical analysis. The first step of the analysis measures how much cost-effectiveness in reducing GHG emissions and private finance intensity have correlated in case of more than 300 CDM and GEF projects (representative sample), while in a second step, a regression analysis tests whether the impact of private finance on cost-effectiveness changes if other determinants of cost-effectiveness are taken into account. The paper also discusses the different implications of mobilizing private finance on effectiveness and cost-effectiveness.

In all chapters, information from 21 semi-structured interviews with experts from national governments, international organizations, development banks and the private sector (see list in Annex 10.1) are used to back up or challenge some of the results from the core analysis.

4 New and additional to what? Options for baselines to assess "new and additional" climate finance[24]

Abstract

All major climate policy agreements – the UN Framework Convention, the Kyoto Protocol, and recently the Cancun Agreements – have stated that climate finance for developing countries will be "new and additional". However, the term "new and additional" has never been properly defined. Agreeing a system to measure a baseline from which "new and additional" funding will be calculated will be central to building trust and realizing any post-Kyoto agreement. We explore eight different options for a baseline, and assess each according to several criteria: novelty to existing pledges, additionality to development assistance, environmental effectiveness, distributional consequences, and institutional and political feasibility. Only two baseline options do well on these criteria and will therefore imply both an increase of climate finance without redirecting aid flows: "new sources only" and "above pre-defined business as usual level of development assistance".

Keywords: climate finance, Copenhagen Accord, development assistance, additionality, UNFCCC

[24] This chapter was published 2011 in 'Climate and Development' 3(3), pages 175-92, with co-authors J. Timmons Roberts & Axel Michaelowa. The version presented here contains few changes and updates.

4.1 Introduction

Since the original Stockholm Earth Summit in 1972, developing nations have feared that attention to protect the natural environment would sideline their ardent quest for meeting basic development needs like health, education and economic growth (Hicks et al., 2008, paragraph 46). Therefore, from the very beginning of international environmental statecraft, gaining these nations' cooperation in efforts to address global environmental issues required promises for funding beyond development assistance (DA). We use the term "development assistance" (DA) here instead of the usual term "Official Development Assistance" (ODA), as ODA as registered by the OECD *includes* climate change mitigation and adaptation funding, while our term "development assistance" (DA) *excludes* climate change mitigation and adaptation funding in order to conceptually clearly separate development assistance from climate finance[25].

Early phrasings described "The Earth Increment", making clear that this funding would not come from other promises, such as the 1970 Monterrey pledge of most wealthy countries to send 0.7 percent of their GNI to assist poor countries overcome their poverty. The phrase "new and additional" financial resources was used at the Rio 1992 drafting of the UN Framework Convention on Climate Change (UNFCCC, 1992), and the language has appeared in every major climate agreement since, including the Kyoto Protocol (1997), the Marrakesh Accords (UNFCCC, 2001), the 2009 Copenhagen Accord (UNFCCC, 2009b) and the Cancun Agreements (UNFCCC, 2010).

The Copenhagen Accord promises USD 30 billion in "new and additional" fast-start finance" over 2010-2012, "scaling up" to USD 100 billion a year of public and private climate finance by 2020. These promises, integrated in the recent Cancun Agreements, are very ambitious given the level of existing flows: USD 159 billion of ODA disbursements in 2009, of which about 6 billion are marked as climate-related, see OECD (2011b). The promises were also fundamental to the reaching of any agreement given the even higher estimates for climate finance needs, e.g. USD 150-300 billion annually by 2030 as estimated by the World Bank (2009). Both wealthy and poor nations agree on the need for such funds: developing countries need funding to grow their economies without becoming locked in to fossil fuel dependence and its high carbon footprint. The most vulnerable developing countries also need substantial funds to prepare for, cope with, and recover from the growing number and intensity of climate-related disasters and incremental changes in local climate.

However as has happened many times before, the terms "new and additional" were never clearly defined, neither in Copenhagen nor in Cancun. "New and additional" to what year as a baseline and to which funds – only those addressing climate change or also development assistance? Given the failure of most industrialized nations to meet their previous pledges of foreign aid, from the 1970 0.7% of GNI pledge to the Gleneagles 2005 promises[26], developing countries question what the term "new and additional climate finance" means in practice. To establish clarity and potentially restore some trust in the integrity of Northern nation commitments, an agreement on the interpretation of "new and additional" is needed.

One can argue that the phrase "new and additional" has been less relevant for global environmental treaties in the past, as official financial payments for developing countries have not reached more than USD 0.15 billion annually per environmental treaty and thus the potential for diversion of large amounts

[25] The reason for using a different term than ODA is that ODA actually includes public climate finance but most people are not aware of this and just use "ODA" as a synonym for development assistance (excluding climate finance). Our term "development assistance" (DA)" is similar to the term "ODA classic" used by Huhtala et al. (2010).

[26] At the G8 summit in Gleneagles 2005 the European G8 members pledged to increase their ODA to 0.7% of their GNI by 2012-2015, while also the US, Canada and Japan made pledges for substantial increase of their ODA (G8, 2005).

of development assistance did not exist. This has significantly changed with Copenhagen where industrialized countries pledged USD 10 billion and more per year. This raises serious questions about both compliance with these substantial pledges and their additionality to development assistance.

When defining "new and additional" climate finance, two major challenges arise. First, countries have very different understandings of the term "new and additional" (Brown et al., 2010; Stadelmann et al., 2010; WRI, 2010). This is also reflected in the different "baselines" industrialized countries use for justifying that their fast-start pledges are "new and additional" (see Table 3). Such a "baseline" can be defined as the level against which a commitment or action is measured. In the context of "new and additional" climate finance, the baseline is the level of finance, above which finance is considered "new and additional".

Table 3: Baselines for "new and additional" used by industrialized countries for fast-start funding

Country	Baseline definition[1]
Australia	Existing aid budgets / no diversion
Austria	Not specified
Belgium	Current ODA, pre-COP15 commitment
Canada	Pre COP15 commitments
Denmark	Above 0.7% ODA/GNI
EU Commission	Above planned programs
Finland	Above 2009 climate finance
France	Not specified
Germany	Not specified
Hungary	Not specified
Iceland	Not specified
Ireland	Not specified
Italy	Not specified
Japan	Not specified
Luxembourg	Above 0.7% ODA/GNI
Malta	Not specified
Netherlands	Above 0.7% ODA/GNI
New Zealand	Not specified
Norway	Above 0.7% ODA/GNI
Portugal	Not specified
Slovenia	Not specified
Spain	Pre COP15 commitments
Sweden	Above 0.7% ODA/GNI
Switzerland	Existing ODA budgets
United Kingdom	Past ODA, max. 10% of climate ODA
United States	Not specified

[1] Source: WRI (2010) and Faststartfinance.org (2011) for: Australia, Canada, Finland, Iceland, Switzerland, United Kingdom. For Sweden and Norway, the "0.7% ODA/GNI" baseline is not explicitly mentioned but is clear given current ODA contributions.

The second issue is that the assessment of "additionality" is methodologically challenging, as both realized by the Commission of Sustainable Development (Yamin and Depledge, 2004, p. 277) and scholars (Dutschke and Michaelowa, 2006).

In this article we address both of these challenges: the question how to reconcile the varying baseline definitions of different parties, and second how to define a baseline that does not face substantial methodological challenges, such as uncertainty of data. The article is structured as follows: First, the criteria for assessing baselines are discussed. Second, a series of options for baselines are analyzed and assessed using five criteria (novelty to existing pledges, additionality to development assistance, effectiveness, distributional consequences, and institutional feasibility). We also examine the practical implications of these baseline proposals, and estimate political resistance and support for each of them.

4.2 Criteria for a baseline

The criteria used here are derived from the climate negotiation texts and the academic literature. The two obvious criteria for setting a baseline are common understandings of the terms "new and additional", such as "novelty to existing pledges" (Müller et al., 2010) and "additionality to development assistance" (Asuka, 2000; Dutschke and Michaelowa, 2006). Furthermore, baselines can be assessed according to the four criteria for climate policies set out by the 4th Assessment Report of the IPCC (Gupta et al., 2007): environmental effectiveness, cost-effectiveness, distributional considerations and institutional feasibility. These four criteria represent research interests of five disciplines: the one of environmental sciences (environmental effectiveness), economics (cost-effectiveness), philosophy/sociology (equity) and political science (institutional feasibility). The four criteria also incorporate the principles of the UNFCCC (1992): environmental effectiveness incorporates the precautionary principle spelled out in the phrase "preventing dangerous climate change"; equity incorporates the "common but differentiated responsibilities and capabilities" principle, as well as the specific needs and circumstances of developing countries; cost-effectiveness can be seen behind the principles that the UNFCCC should promote and not hinder sustainable development and an open international economic system. While institutional feasibility is not representing any UNFCCC principle, it is clear that baselines, which fulfill all other criteria, need also political acceptability and institutions to ever be implemented. The importance and definition of each of these criteria is explained in the following.

4.2.1 Criterion 1: Additionality to development assistance

The discussion about development assistance baselines began essentially with the pledge of "new and additional" resources in Rio 1992. The Commission on Sustainable Development unsuccessfully tried to establish an indicator for "new and additional" financial resources in 1995 (Yamin and Depledge, 2004, p. 277). The question was further taken up in the discussion on "diversion" of development assistance in the context of CDM projects from 2000 onwards (Asuka, 2000; Dutschke and Michaelowa, 2006). Apparently, the lessons from this debate did not inform the discussion about climate finance that has taken off since 2007. Here "additionality" is an often used term but its meaning has never been clearly defined. Some understand "additional" as "additional to existing aid flows", while most developing countries and NGOs understand it as additional to existing developed country promises to provide 0.7% of their GNI as ODA (Dutschke and Michaelowa, 2006; Oxfam, 2009; Müller et al., 2010). We use a middle-ground definition: *climate finance is additional if it leads to an increase both compared to present and projected future development assistance (DA),* while DA does not include the climate finance part of ODA (see footnote 25). Climate finance may be counted as ODA but the development assistance (DA) part of ODA is not allowed to be reduced below BAU projections. This is a theoretically clear definition but international institutions as well as recipients may find it difficult to assess the BAU levels of DA. Donors may have some incentives to not reveal the real BAU level of DA, similar to the distortion of investment parameters by project owners in the context of CDM projects.

4.2.2 *Criterion 2: Novelty to existing flows and pledges*

According to Müller et al. (2010) "new" mainly refers "to funds which are separate from those that have already been promised, for climate change or as overseas development assistance". However, "novelty" is also increasingly understood as new funding sources such as a tax on financial market transactions, auctioning of emission allowances or levies on air and maritime transport (Müller et al., 2010). The idea behind defining novelty as "new sources" is that industrialized countries' government budgets, especially the part dedicated for developing countries, are always subject to domestic pressures (Fischer and Easterley, 1990; Bulír and Hamann, 2008; Doornbosch and Knight, 2008). Therefore, governmental funds for climate finance can always be funds that had already been pledged in the past, or promised as development assistance; and funds are only then really "new" if they stem from new sources other than government pledges. While the "new sources" definition clearly has its merits we define "new climate funds here *as funds that have not yet been promised for supporting developing countries' climate or development actions*, following the most common understanding according to Müller et al. (2010).

4.2.3 *Criterion 3: Environmental effectiveness*

The IPCC (Gupta et al., 2007) lists environmental effectiveness as the first criterion to evaluate environmental policies. Environmental effectiveness is understood here as the level of climate change mitigation and adaptation achieved[27]. Assuming that an increase in funds leads to an increase in mitigation and/or adaptation[28], a baseline is environmentally effective if it increases funds useable for climate mitigation and adaptation compared to business as usual. On one hand, we can assume that the more stringent a baseline is regarding novelty to existing climate funds, the more climate funds will be paid. However, once the sum of the baseline and the new climate funds reaches the maximum level of climate finance donors are willing to pay in order to meet international standards (see also Figure 12), a further strengthening of the baseline will not increase funding or even lead to decrease[29]. On the other hand, decreasing the stringency for additionality to existing development funds may also enhance climate funds as lenient development baselines make diversion to climate funds more probable.

A criterion linked to environmental effectiveness is "cost-effectiveness". We exclude this criterion in the following, as the influence of the baseline on cost-effectiveness is difficult to judge, for two reasons: First, the way a baseline is set does not influence how the funds are spent. Second, a baseline leveraging more funds can have different impacts: scale and learning effects linked to the size of the programs may increase cost-effectiveness, while the exhaustion of cheap options can decrease it.

[27] Strictly speaking, only mitigation has an "environmental" impact by reducing climate change, while adaptation has mainly direct economic benefits. However, as most climate finance is used for mitigation, we can easily assume that climate finance enhances environmental effectiveness.

[28] This is a weak assumption in our view: If international mechanisms are stringent enough, climate funds will be spent on climate-related activities. Assuming minimal knowledge on mitigation and adaptation, environmental benefits per unit may decrease with increased finance but will stay positive. In few cases, climate funding may actually decrease environmental effectiveness, e.g. in case of maladaptation or if funds are allocated to energy efficient coal power plants, which would have been built anyway. However, it is highly probable that such negative effects will not outweigh the positive effects of climate finance.

[29] We assume here that industrialized countries indeed react to the internationally agreed level of the funds but only until a specific level. This assumption would e.g. hold for the 0.7% of industrialized countries' GNI being pledged as goal for development assistance: while this goal is often used to motivate donors to increase their funds, the level of 0.7% of GNI seems to be above the level that industrialized countries are – at maximum – willing to contribute. Therefore, moving the target beyond the 0.7% of GNI should not lead to additional funds.

4.2.4 Criterion 4: Distributional considerations

As any economic policy measure, climate policy measures will have distributional impacts. For this reason, commonly used terms in the climate policy context are “equity” and "fairness” (Ringius et al., 2002). Distributional considerations have focused on the phrase “fair burden sharing” (see e.g. Müller et al., 2009). In our study we consider distributional questions by assessing the impact of different baselines on burden sharing between developed and developing countries. We assume that current climate policy pledges (mitigation and finance) of developed countries are way below their fair share of the burden, when considering various burden sharing studies[30] (Pan, 2003; Den Elzen et al., 2005; Bernard et al., 2006; Baer et al., 2007; Marklund and Samakovlis, 2007; Den Elzen and Höhne, 2008; Chakravarty et al., 2009). *A baseline, therefore, adequately addresses equity the more it shifts the burden away from developing nations that are least responsible for the problem and least capable to adapt.*

4.2.5 Criterion 5: Institutional feasibility

The last IPCC criterion for environmental policy is institutional feasibility, or broadly speaking the question of whether the theoretical ideas can be implemented, given the existing institutions and political considerations, internationally as well as nationally. We divide institutional feasibility into three sub-criteria: a proposed method’s political acceptability, its transparency, and whether it interferes with other international regimes.

Criterion 5a: Political acceptability (North-South)

Not even the most objective definition of a baseline will be feasible if it is not accepted by the major Parties to the UNFCCC. Political acceptability is an important precondition for participation, a key criterion for success of an environmental regime (see e.g. Wettestad, 1999). Participation is a widespread concern for the climate regime after the US did not ratify Kyoto (Barrett and Stavins, 2003); thus the impact of future non-participation has been studied as well (Keppo and Rao, 2007; van Vuuren et al., 2009). As the world’s CO_2 emissions are about evenly split between developed and developing countries (PBL, 2009; Olivier and Peters, 2010), while the share of developing countries’ emissions will further rise in the future (van Vuuren et al., 2009), the acceptability for both Northern as well as Southern countries has to be assured. Under a universal international climate treaty, horse trading of climate finance and mitigation targets would be possible, which would allow one to bring baseline stringency in as one parameter of negotiations. However, the lack of progress in international climate negotiations makes the fragmentation of the regime more and more likely and thus reduces horse trading options. Furthermore, the room for concessions is narrow at the moment, as the North is dealing with the consequences of a major economic crisis and the South is harboring mistrust due to disappointments on finance pledges[31]. Therefore, political acceptability of baseline stringency as part of the climate finance negotiations is a major criterion; *a baseline will be politically feasible if it is expected to be acceptable to the major Parties to the UN framework convention.*

[30] Also advanced developing countries such as China, South Korea or Mexico may have to contribute. However, the bulk of climate finance will have to come from industrialized countries.

[31] For a recent critique of India and South Africa that industrialized countries do not deliver promised climate finance, see Jebaraj (2011).

Criterion 5b: Transparency: clarity of definition and availability of data

The importance of transparency for environmental regimes is acknowledged by academic scholars, governments and NGOs (Mitchell, 1998). Transparency helps for achieving and assessing compliance and effectiveness, which has been studied both for security and environmental regimes (Mitchell, 1998; Roberts and Parks, 2007). Transparency is important in many ways for the climate regime: e.g. related to greenhouse gas inventories or the negotiation process[32]. Regarding transparency of finance, financial contributions have haphazardly been included in national communications, but transparency only came to the forefront when the notion of "nationally appropriate mitigation actions [...] supported and enabled by technology, financing and capacity-building, in a measurable, reportable and verifiable manner" was included in the Bali Action Plan (UNFCCC, 2008b). By this wording, not only the actions of developing but also the financial support of developed countries was to be measured and verified. While the Parties are still negotiating the way this has to be done, scholars have already identified the need for more transparency: the new climate funds set up in the last few years lack transparency (Stewart et al., 2009) and more transparent guidelines for finance reporting are needed under the UNFCCC (Roberts et al., 2010b; Tirpak et al., 2010). Such guidelines seem especially important as the current way of labeling ODA as climate-related (labeling by donors using the OECD's Rio Markers) has been inconsistent and politically-driven in the past (see Michaelowa and Michaelowa, 2011a).

The transparency of a baseline is given if international organizations or parties can easily assess whether the baseline for climate finance has been complied with. This assessment is possible if two conditions are met: first, the definition of a baseline must be clear to avoid renegotiation and redefinition. Second, the data for measurement and verification must be accessible and assessable. Therefore, we will *assess the transparency of baseline definitions by both analyzing the clarity of the definition and the availability of data.*

Criterion 5c: Consistency with other regimes

Rules within the climate change regime may not be consistent with well-established rules of other regimes. This has especially been studied for the case of border carbon adjustment and the trade regime (see e.g. Charnovitz, 2003; Brewer, 2004; Biermann and Brohm, 2005): e.g. taxes on embodied carbon in imported goods, which can be seen as contributing to the precautionary principle within the climate regime, are not clearly consistent with WTO principles on free trade. In the case of climate finance, we may have some interference with the rules for accounting development assistance. The wording of "new and additional" in the climate regime may imply a separation of development and climate funds (Huhtala et al., 2010). However, the OECD has established rules that all financial transfers with a certain level of concessionality qualify as Official Development Assistance (ODA). Therefore, a decision to not count climate funds as ODA would heavily interfere with the established OECD rule, which is backed by major donor preferences[33]. Beside the definition of ODA, a baseline definition may also include assumptions on the pledged level of ODA, which is a large intervention into the development assistance regime as well, given that donors are used to having sovereignty on ODA commitments. In contrast, honing the definition of climate finance is less interfering into the development regime, as the existing Rio Markers for both mitigation and adaptation (OECD, 2009) are quite new, not defined in detail, and the definition is sometimes poorly understood by donor staff. Therefore, *we define the consistency with other regimes as the level of consistency of climate regime rules with well-established rules in the development assistance regime.* Major interferences would be a change of the ODA definition or fixing the level of ODA commitments.

[32] See e.g. the Cancun summit: the success was partly related to the transparent procedures, applauded by many parties (IISD, 2010a).

[33] A senior Northern government official reported that his country advocated the change of the ODA definition in order to separate climate funding. The attempt, however, had no chances.

4.3 Options for a baseline

In this section we describe eight baseline options and assess how well they perform on the criteria just listed. Seven of the analyzed baseline options are the ones mentioned in the literature and the negotiations: 0.7% of GNI, no baseline, new channels, no ODA counts, current climate finance, current development assistance and new sources. Furthermore, we propose a new, potentially promising definition: projection of development assistance and climate finance.

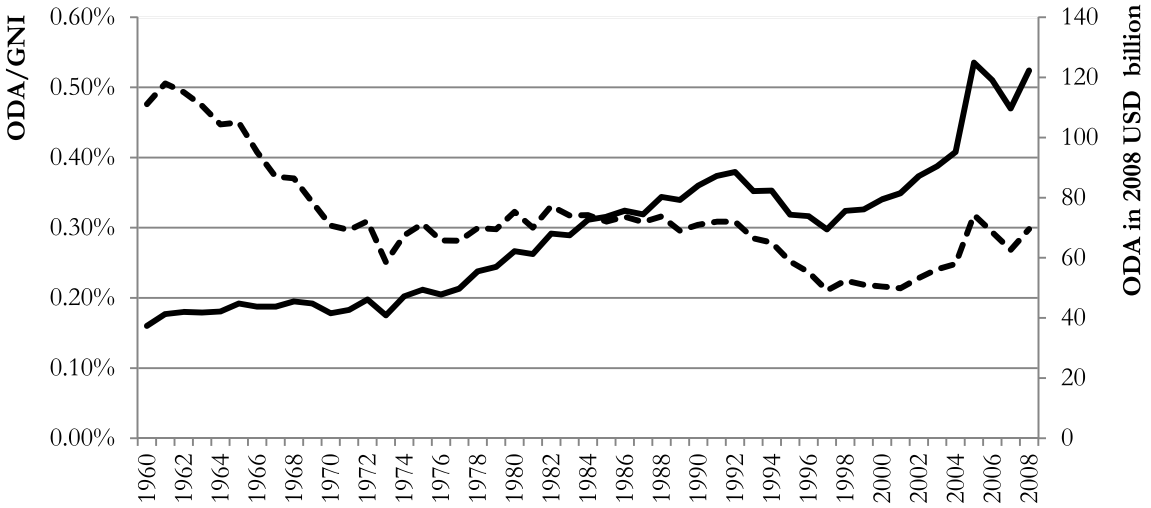
4.3.1 Option 1: 0.7% of GNI

Many developing countries prefer that the ticker for new and additional funding start only after countries have contributed 0.7% of their Gross National Income (GNI) to ODA (Ballesteros and Moncel, 2010). The target that developed countries provide 0.7% of their GNI as ODA has first been mentioned in the Report of the Commission on International Development (Pearson, 1969), without any clear explanation on how this has been calculated (Clemens and Moss, 2005). The 0.7% target has been several time restated, e.g. at the "Earth Summit" in Rio de Janeiro 1992 and importantly in the final declaration of the UN's International Conference on Financing for Development in Monterrey 2002, attended by many heads of state (Clemens and Moss, 2005)[34]. Until now, the 0.7% has been reached by only a very small number of countries, and the highest overall ratio of ODA to GNI has been achieved before the target was even set (see Figure 9). The 0.7% GNI threshold is also a favorite of European countries like Norway and the Netherlands that already meet this ODA standard.

Although this threshold seems transparent and takes into account past pledges by developed countries, it is not viable for two reasons. First, many developed countries will in the next few years neither accept nor reach this threshold – especially the United States, with less than 0.2% of its GNI going to ODA. In case of countries that are far away from the 0.7% level, the wording "new and additional" will not put any pressure on them to spend on climate finance, as anyway, none of their funding is seen as additional. Second, countries like Sweden and Denmark, which today exceed the 0.7% mark, may just divert existing ODA commitments and call them new and additional climate finance. The non-feasibility of this baseline also applies to CDM additionality (Dutschke and Michaelowa, 2006).

[34] Industrialized countries actually for a long time never promised to reach the 0.7% target but only to make efforts to attain it (Clemens and Moss, 2005). This changed when the EU pledged that the old member states reach this level by 2015 (EU, 2005).

Figure 9: Historic ratio of ODA to GNI (dashed line) and historic level of ODA (straight line)



Sources: OECD (2010a) for ODA and WB (2010) for GNI

4.3.2 *Option 2: No agreed baseline*

Most industrialized countries favor having no agreed baseline, so that each contributor defines its own baseline. This option is clearly not acceptable for developing countries, and "additionality to development assistance" is not given. Furthermore, the definitions will be arbitrary, comparing funding across nations becomes very difficult, transparency is hardly given, and diversion of development assistance is likely. This option is the current state of affairs at this writing, as each donor has its own or even no definition of the baseline (WRI, 2011)

4.3.3 *Option 3: New UN channels only*

A simple option for avoiding this situation with unclear baselines is to count only funding disbursed through new UN channels, such as the Adaptation Fund or the planned Green Climate Fund, as wished by many developing countries. Although technically clear, the "new channels only" approach reduces flexibility for contributors and makes it less acceptable to them to use the term "new and additional" or leaves them less willing to disburse climate funds. Some existing channels may be better suited for effective use of certain types of flows or certain efforts to address climate change. This approach could have absurd consequences if old commitments are simply redirected into new funds.

4.3.4 *Option 4: No ODA counts*

Another straightforward option would allow using the best channels and mechanisms, but would not count ODA money as climate finance, to clearly separate between development and climate funds. This option is favored by many developing countries, who want climate finance to be above ODA (Ballesteros and Moncel, 2010). This approach forces contributors to decide whether the main goal of funding is development or climate related. Double-counting could be avoided and transparency enhanced. Additional administrative costs of separately accounting climate funds from ODA are minimal if built on existing accounting systems, e.g. the only change to the existing OECD system would be that funds marked with the climate change Rio Marker would not be counted as ODA but reported as "climate finance". However, the quality of the Rio Markers needs to be improved, see Michaelowa and Michaelowa (2011a). We may expect an improvement of the Rio markers, if climate-marked funds are not counted as ODA anymore, as development ministries will have an interest that development projects are not marked as climate projects.

Despite the advantages of this approach, it is rejected by most industrialized countries, as they prefer to use climate funds to reach their ODA targets (see footnote 33). Developing countries also argue that climate finance should be "mainstreamed" into existing development assistance but this is a non-consistent argument as mainstreaming in itself is not constrained by separate accounting of development and climate funds[35]. However, a further argument against this baseline approach is that it would be inconsistent with the well-established rule in the development assistance regime that all concessional flows can be counted as ODA.

A softened version of the "no ODA counts" option is the idea of former British Prime Minister Gordon Brown to limit the climate finance that can be accounted as ODA to 10% of overall ODA contribution. All climate finance beyond this 10% needs to come from other sources to be seen as "new and additional" (Brown et al., 2010). We do not treat this as a separate option here, as the 10% seems to be an artificial number that made sense for the UK Prime Minister at a given time, as the climate share of his aid budget was not yet close to the 10%. We never heard that this number has been repeated by any other nation.

4.3.5 Option 5: Current climate finance

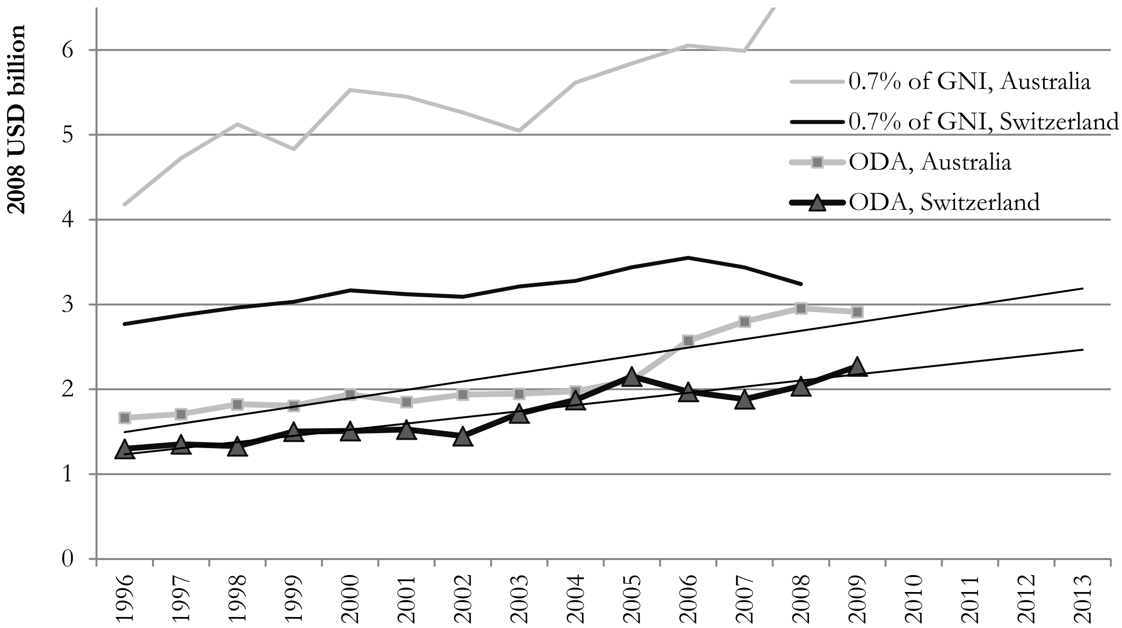
A baseline acceptable to contributors (and according to Brown et al. (2010) supported by Germany) may be "current climate finance": the existing climate funds and those pledged before Copenhagen would define the fixed baseline. This could be the final year before Copenhagen (2008 or 2009), or a five-year average such as 2005-2009. This interpretation of "new and additional" has some precedent in the climate negotiations, as the Marrakesh Accords (UNFCCC, 2002: 43) included the wording "funding that is new and additional to contributions, which are allocated to the climate change focal area of the Global Environment Facility and to multilateral and bilateral funding". On the downside, with this model the diversion of development-oriented aid is possible, and information on current climate finance is scarce. In three analyzes, we have attempted to quantify current levels of climate finance (Roberts et al., 2008; Roberts et al., 2010a; Michaelowa and Michaelowa, 2011a). Many definitional problems arise, showing starkly conflicting numbers between OECD "Rio Marker" totals and those of our independent categorizations at the project level. Therefore, the criterion of transparency is currently not given, both in terms of clarity of definition and availability of data. However with clear definitions and sufficient resources, such a baseline could be constructed for major contributor nations in the future.

[35] Separate accounting just means that in case of a larger development program, in which climate change concerns are mainstreamed, donors have to decide which part of the funding is seen as development-related and which part is counted as climate finance. This accounting exercise by itself should not have an impact on the project design.

4.3.6 *Option 6: Current development assistance and climate finance*

An additional option is the idea to see current development assistance and climate finance as baseline, which is close to the wording in the Marrakesh Accords (UNFCCC, 2001) of "funding that is new and additional to […] multilateral and bilateral funding". Under this definition, all contributions above current development assistance and climate finance (= above current ODA[36]) may count as climate finance. Two contributor countries, Australia and Switzerland, use a similar definition to this when saying that their fast start pledge is part of an increase in ODA (WRI, 2010). This essentially means that all climate finance can be called "new and additional" as long as ODA is increasing. However, this definition has some fundamental flaws: ODA has been increasing over time and is expected to increase even more in the future as most countries attempt to get closer to their 0.7% of GNI target or their Gleneagles 2005 promises. Australia and Switzerland both fit this pattern: their ODA has increased in the last few years, they have not yet met the 0.7% target, and it can be projected that their ODA will increase in the future (see Figure 10). This baseline will, therefore, not fulfill the criterion of "additionality to development assistance" and will not be acceptable for developing countries.

Figure 10: Possible projections of development assistance (straight line projections)



Source: OECD (2010a) and WB (2010) for years 1996-2009, straight line projections for the years 2010-2013, based on the data from the years 1996-2009 (not controlling for economic development)

[36] As all public climate finance to developing countries is counted as ODA, the sum of DA and public climate finance is ODA.

4.3.7 Option 7a: Updated projections of development assistance and climate finance

Instead of current development assistance and climate finance levels, updated projections of development assistance and climate finance could be used as a baseline, which is a new option we propose (although Huhtala et al. (2010) mean a similar baseline when proposing "benchmarking"). In this case, BAU funding levels would be re-assessed every year or two, taking into account current economic growth in industrialized countries and development assistance commitments. For example, country X plans to increase ODA to USD x billion per 2020 if its economy is steadily growing. However, an economic crisis just before 2015 makes the reaching of this target impossible. Therefore, the country will lower its projected baseline for 2020 and the international community may allow the country to lower its baseline for 2015. This option may be acceptable to contributors, as it could allow future spending on climate finance to fall during economic downturns. Of course, obligations would also increase in strong growth years. Although this method is theoretically close to the perfect assessment of "new and additional", it might fail at creating trust between parties, as developed countries may be suspected of gaming the baseline, and because baselines are renegotiated every few years. Therefore, we judge this baseline to not fulfill the criteria of "clarity of definition" and "political acceptability in the South".

4.3.8 Option 7b: Pre-defined projection of development assistance and climate finance

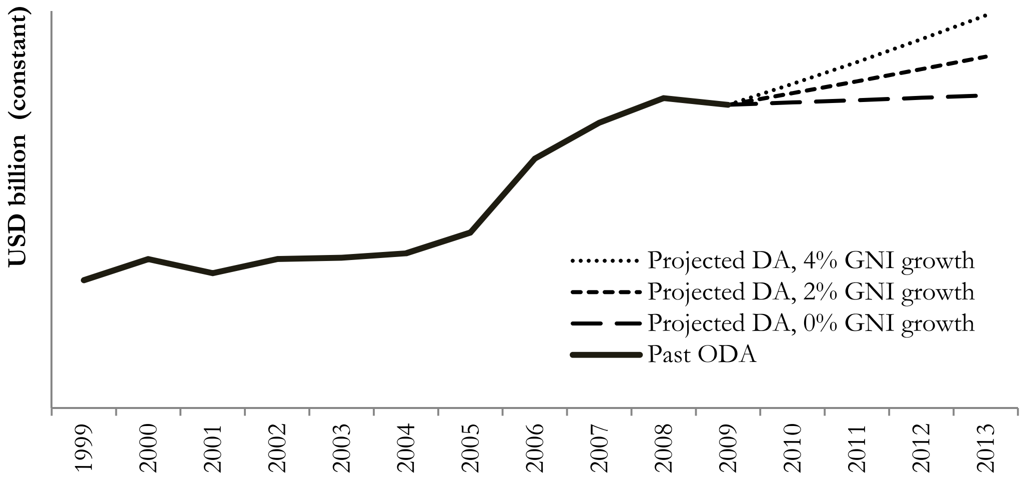
A variant baseline using pre-defined projections of development assistance would avoid this permanent re-negotiation by defining the projected BAU level of development assistance and climate finance in advance, according to a realistic growth path. The pre-definition task would create a debate on which growth path is most realistic—very recent years or a longer-term trend[37]. Industrialized countries may be concerned about agreeing to specific levels of development assistance and climate finance without knowing their future GNI growth and related tax income. It is relatively straightforward, however, to use a formula that takes into account real GNI growth in later years[38] (see Figure 11 for illustration). The GNI dependence of the funds would be a downside for developing countries, but by avoiding re-negotiation of the formula they would benefit from better predictability.

We do not see any major drawbacks beside some interference with the development assistance regime, as a projection of ODA is defined. This interference is, however, not very severe, since projections do not change official definitions like ODA.

[37] For example in Figure 10 Switzerland shows a steeper increase over the final three years than over the trend – Australia's ODA was flat and then dropped in 2009, but a longer-term trend since 1996 gives it the steepest slope of the two.

[38] This pre-definition with later adjustment is similar to the case of the Clean Development Mechanism where the baseline is estimated before the project is registered but it is adjusted ex-post according to some predefined formula (e.g. the production level or the units installed).

Figure 11: Projected development assistance and climate finance, adjusted to GNI (notional example)



Source: Own graph, assuming ODA is projected to rise (simplified assumption of gradual increase; in reality development assistance will fluctuate due to economic cycles)

4.3.9 *Option 8: New sources only*

A final baseline definition, also proposed by Huhtala et al. (2010) for defining "new" is "new sources only", which is actually an alternative definition to "novelty" we rejected earlier. It combines all issues: novelty, additionality and acceptability. This baseline would count new sources only, meaning that only assistance from novel funding sources—such as international air transport levies, currency trading levies or auctioning of emission allowances—would be seen as new and additional. Such funds are new by definition, and they are likely to be additional to development assistance, as it is improbable that new funding sources – particularly the ones related to pricing carbon emissions – would be used for development assistance without a climate policy regime[39]. The obvious drawbacks are that it inflexibly bars the use of effective current funding streams, and would somewhat arbitrarily define which sources are new. Although we believe that this baseline could be acceptable for contributors, they have ruled it out for 2010-2012 "fast-start" financing, which will draw on existing sources such as the general budget. Therefore, the "new sources only" option is probably one for longer-term (post-2012) climate finance, especially the ramping up of climate finance for the 2020 promise of USD 100 billion a year, for which the UN Secretary-General's High-level Advisory Group on Climate Change Financing is suggesting especially new sources such as carbon taxes, auctioning of emission allowances or levies on international transport (UN, 2010).

[39] The risk of "diverting" development funds is most likely in cases of sources that are not related to climate change, e.g. in case of a new financial transaction tax.

Summary of options

When assessing the different baseline options with the criteria discussed (Table 4) most options do not fulfill at least one criterion. Only the baseline options “above a pre-defined projection of development assistance and climate finance” and “new sources only” can guarantee some level of additionality, novelty, and acceptability by parties, as well as transparency and consistency with other regimes.

The option “pre-defined projection of development assistance and climate finance” does not perform very well on any particular criterion, but it also lacks any major drawbacks. The main challenge is to predefine projections of ODA. Such projections would not mean a change of existing regime rules but to introduce a new rule, which will have to be agreed at the head of state level. The second option with no negative rating on any criterion is “new sources only,” which we consider very promising given that there is international agreement that new sources are needed. Both the Copenhagen Accord and the Cancun Agreements specify that alternative sources of finance are to be included. Therefore, the “new sources” baseline option may have political support but it is hardly feasible in a strict sense: totally refraining from using traditional aid budgets will decrease flexibility on the donor side and may, therefore, limit both acceptability in the North and lower the overall climate funds (and, therefore, environmental effectiveness). Furthermore, many developing countries wish that most funding is coming from public sources (see e.g. IISD, 2010b), whereas “new sources” also include private funds. Therefore, a less strict baseline, e.g. the use of “at least 50% new sources” or the combination of the two feasible options (“above pre-defined projection of DA or from new sources”) may be more promising.

Table 4: Assessment of baseline options

Criterion	1) Additional to develop't assistance	2) New to existing flows and pledges	3)Environmental Effectiveness	4) Distributional considerations	5a) Political acceptability (North)	5a) Political acceptability (South)	5b) Transparency: Clarity of definition	5b) Transparency: Availability of data	5c) Consistency with other regimes
Means of assessment	No DA decrease	No double counting	Funds for mitigation & adaptation	Shift of burden away from South	Public statements	Public statements	Clarity	% available	Consistency with rules of the DA regime
Baseline Option									
1) 0.7% GNI	+	+	-	+	-	+	+	+	-
2) No agreed baseline	-	(-)	(+)	(-)	+	-	-		+
3) New UN channels only			-		-		+	+	+
4) No ODA counts	+		(-)	+	-	+	+	+	-
5) Current climate finance	-	+	+			-	-	-	+
6) Current DA & climate finance	-		(+)		+	-			
7a) Updated projection of DA & climate finance	+			+		-	-		(-)
7b) Pre-defined projection of DA& CF	+			+			+		(-)
8) New sources only		+	(-)	+	(-)	(-)	+	+	+

Criterion given, (+) rather given, (-) not clearly given, – clearly not given; blank cells means no clear rating. DA = development assistance, CF = climate finance

4.4 Discussion: challenge to raise climate finance without redirecting aid flows

The assessment of the different baseline option has shown that hardly any of the baselines meets all criteria (additionality to aid flows, novelty, environmental effectiveness, political acceptability, and transparency).

The challenging situation can illustrated with Figure 12 that shows the relationship between the baseline stringency (x-axis) and the level of funding (y-axis); depending on the baseline stringency, a different amount of finance is seen as ODA and existing climate finance (white area below the bold line) and "new and additional" climate finance (grey-shaded area above the line). We assume here that both the current and projected development assistance and climate finance levels do not exhaust the maximum budget that a country is willing to spend on development assistance and climate finance together. Clearly, the assumption of a budget constraint budget is a proxy that only holds if several parameters, e.g. composition of the government, voters preferences are kept stable[40].

Figure 12 illustrates that only limited baseline options can lead to an increase of climate finance without implying a diversion of DA or re-counting of already planned climate finance. If the baseline stringency for "new and additional" is below the projected level of finance, then industrialized countries can increase climate finance at the expense of DA (or re-label "old" finance as "new") as far as the baseline permits, as long as minimum level of DA finance wished by the electorate is guaranteed[41]. If the baseline is more stringent than the projected level of DA and climate finance, industrialized countries can increase development assistance spending beyond the projected level until the entire budget is spent, in order to be able to generate "new and additional climate finance." If the baseline stringency goes beyond the budget constraint, then the country can – by definition – not spend anything on "additional" climate finance, and – as long as the government is mainly interested in meeting international obligations – development assistance and climate finance abruptly decreases to the projected level.

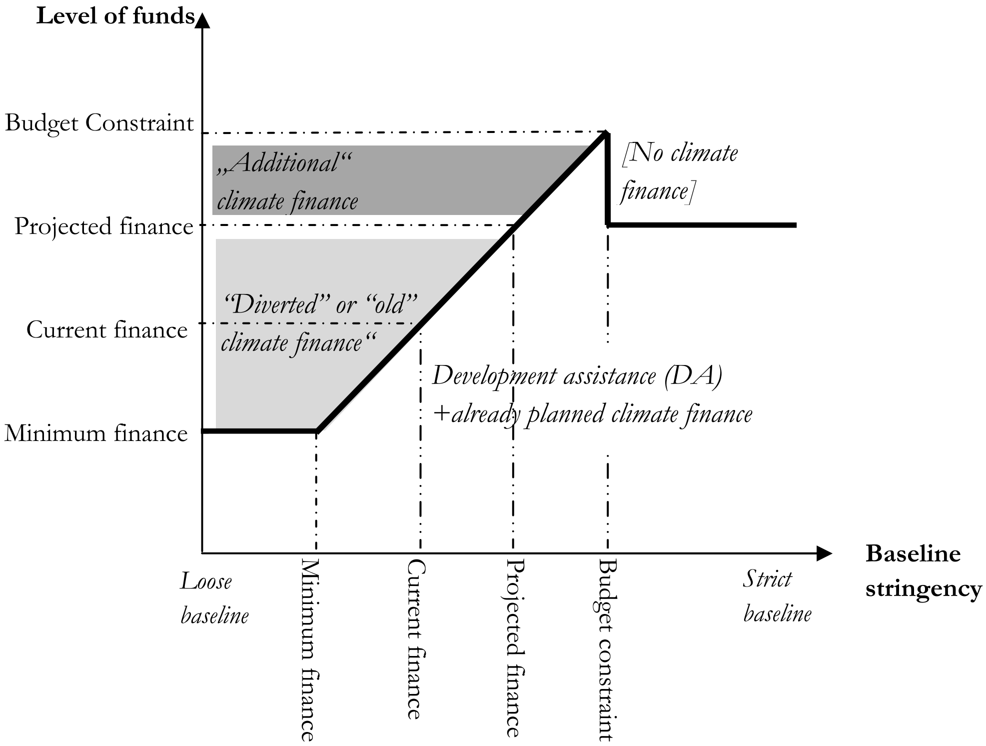
Therefore, only baselines between the projected level of DA/climate finance and the budget constraint lead to an increase of climate finance (criterion of "environmental effectiveness") without diverting development assistance (criterion of "additionality" and "novelty") or re-counting of already pledged climate finance (criterion of "novelty"). Baselines that meet these criteria are the projected BAU level of finance and "new sources", as the later essentially weakens the budget constraint.

Figure 12 also depicts the criterion of political feasibility. The budget constraint is essentially the limit of political feasibility in the North, while the projected level of funding equals the minimum baseline level the South is willing to politically accept.

[40] There are, however, at least two historic arguments that governments cannot raise assistance to developing countries beyond a specific level, given the preferences of the electorate. First, aid budgets have been heavily determined by external influences such as the global economic situation and unique historic events such as the end of the Cold War (see e.g. Round and Odedokun, 2004; Mold et al., 2009). Second, the 0.7% GNI goal for ODA flows has only been met by few countries despite international and national pressure; some countries have not even come close to it.

[41] This minimum level will hardly be much below the current level of DA funding; only if the government faces a strict obligation to meet climate finance pledges, it may reduce – as compromise – some of its development assistance.

Figure 12: Impact of climate finance baseline in case of budget constraint



4.5 Conclusions

The current state of no transparency on novelty and additionality of climate finance pledges will perpetuate mistrust in the climate regime. Many options for a baseline for a definition what "new and additional" means have been put forward but the parties to the UNFCCC have not yet agreed on any. From the climate negotiation texts and the academic literature we derive that a meaningful and successful baseline must at least fulfill the following criteria: novelty, additionality, equity, acceptability, transparency and consistency with other regimes. We conclude that only two of the assessed baseline options are not violating any criterion excessively: "Above pre-defined projection of development assistance and climate finance" and "new sources only". It is, therefore, warranted that parties consider those two baseline options instead of restating their old extreme positions of either no baseline or a threshold of 0.7% of GNI going to ODA.

Procedurally, the discussion on a baseline should be included either in the Ad-hoc Working Group on Long-term Cooperative Action under the Convention, or as subtask for the new Standing Committee on Climate Finance. If a global agreement on a single baseline definition is not possible, a second-best solution would be to oblige each contributor to transparently declare its own baseline definition, while providing guidance on needed data for each baseline option. Both a common as well as individual baselines could be part of the "enhanced common reporting methodologies for finance and tracking of climate-related support", for which modalities and guidelines should be developed according to the Cancun Agreements (UNFCCC, 2010, paragraph 46).

Both industrialized and developing countries can do their part to reach a compromise: while industrialized countries could agree on elaboration of an internationally defined baseline or at least attach a baseline to each of their pledges, developing countries may acknowledge that it was almost impossible for industrialized countries to contribute USD 10 billion of "new and additional" funding in 2010, as the 2010 budgets have mostly been determined before Copenhagen. More scrutiny may be applied to the figures for 2011 and 2012. Meanwhile, the "scaling up" period from 2013 (when fast-start finance is past) and 2020 (when USD 100 billion/year is pledged) requires a sharp increase of about USD 10 billion/year: deciding a baseline is critical for financing action during this period.

In the end, defining a baseline for "new and additional" is just one of many important pieces in the larger jigsaw of climate finance. The new Green Climate Fund board will have to design the detailed governance structures and modalities for access for the Fund. However, this new fund will only be part of the various bilateral, multilateral, private and even South-South flows that have to do with financing climate change mitigation and adaptation. For realizing the full potential of climate finance, parties to the UNFCCC have to decide on a definition of "climate finance" and on rules and institutions on how to track it. In parallel, new and acceptable financing sources have to be identified. The new Standing Committee on Climate Finance could deliver important preparatory work for decisions on definitions (both climate finance and "baselines"), tracking modalities and new sources.

5 International climate finance as driver of renewable energy diffusion – comparing official claims with macro level evidence

Abstract

Renewable energies (RE) in developing countries are financed by two main mechanisms under the UN Climate Convention: public funds are flowing through the Global Environment Facility (GEF) while mostly private funds are invested through the Clean Development Mechanism (CDM). GEF and CDM report substantial effectiveness of their funding in promoting RE but micro level studies have questioned these claims. This paper uses a macro perspective to analyze whether GEF and CDM indeed overestimate their impact on renewable energy diffusion. For this purpose, Fixed Effects, Random Effects and Generalized Methods of Moments models are used to identify the determinants of grid-based renewable energy diffusion, using a dataset covering 20 years and more than 120 developing countries. The models estimate that CDM and GEF's effect is substantially lower than officially reported when controlling for economic development, national policies, dependence on foreign oil and resource endowment. The only exception is the case of biomass power where CDM is, according to the models, more effective than officially reported. The results are consistent with evidence from case study research and suggest that reforms of both CDM and GEF are needed.

Keywords: Renewable Energies, Developing Countries, Clean Development Mechanism, Global Environment Facility, Effectiveness

5.1 Introduction

This study analyzes international climate finance as driver for renewable energies in developing countries. Renewable energies are seen as important technologies for transformation to sustainable and low-carbon energy systems (see e.g. Pacala and Socolow, 2004; Edenhofer et al., 2011; Krey and Clarke, 2011).

Given their importance for climate change and sustainability, there is a wide range of comparative studies analyzing the determinants of renewable energy (RE) diffusion (Carley, 2009; Marques et al., 2010; Marques et al., 2011; Popp et al., 2011). Most of these studies have focused on industrialized countries and neglected developing countries, which are particularly important in scenarios of future diffusion (Krey and Clarke, 2011). For developing countries we mainly find case studies and qualitative analysis (e.g. Martinot et al., 2002; Goldemberg et al., 2004; Reddy and Painuly, 2004; Yu et al., 2009). The only known comparative analysis of RE diffusion in developing countries are the ones of Brunnschweiler (2010), who identifies the financial market as important determinant, and Sadorsky (2009), who analyzes the impact of income per capita for 16 emerging economies.

All of these quantitative studies have neglected the role of international climate finance, which we define here as "international financial payments, directly or indirectly mobilized by industrialized countries governments that cover costs of climate change mitigation and/or adaptation in developing countries". Such international climate finance substantially supports the deployment of renewable energies in developing countries both via public channels (Zerriffi and Wilson, 2010; Dixon et al., 2011) and the carbon market (Lewis, 2010; Schneider et al., 2010).

Existing studies on the impact of international climate finance on RE deployment are based on micro-level case studies (Schneider, 2009b; Lewis, 2010; Zerriffi and Wilson, 2010) and have not taken into account important macro level drivers such as technology potential (Marques et al., 2011), financial markets and resources (Sadorsky, 2009; Brunnschweiler, 2010), energy demand (Carley, 2009), knowledge (Popp et al., 2011) and climate and energy policies (Lewis and Wiser, 2007; Carley, 2009).

This study tries to fill this research gap by analyzing the influence of international climate finance on macro level diffusion of renewable energies in developing countries. We focus on the impact of the Global Environment Facility (GEF) as public funding institution and the Clean Development Mechanism (CDM) as market-based mechanism, as these are the main financing channels for RE linked to the United Framework Convention on Climate Change (UNFCCC).

The paper starts off by describing the role of CDM and GEF as international climate finance channels, comparing their size to international development funding promoting RE. Then we explore theoretical reasons why the CDM and GEF may be successful in promoting renewable energies but why their impact may be overestimated by official numbers. We also explore reasons whether CDM or GEF can be expected to be more effective per unit of funding. After this the empirical strategy and data is presented, followed by the results for five different types of renewable energies and a discussion of the results.

5.2 International climate finance channels promoting renewable energies

5.2.1 *The Global Environment Facility (GEF) and other public institutions*

Under the UN Framework Convention on Climate Change (UNFCCC), the wealthiest countries (Annex II) have the obligation to pay for any climate change mitigation related measures that are agreed between developing countries and operating entities of the UNFCCC's financial mechanism (UNFCCC 1992). Similar to other environmental conventions (biodiversity, desertification), the Global Environment Facility (GEF) was chosen to be the operational entity of the UNFCCC's financial mechanism, and in the last 20 years around 1.3 billion USD have been committed to support renewable energies, which is the main climate change funding area besides energy efficiency (Stadelmann, 2009). Table 5 shows that among all RE technologies, mostly biomass, solar and wind power have been promoted, while less than 50% of funding committed in the period 1992-2009 had been disbursed by the end of 2008.

Table 5: Share of grid-based renewable energy among all GEF projects (at the end of 2009)

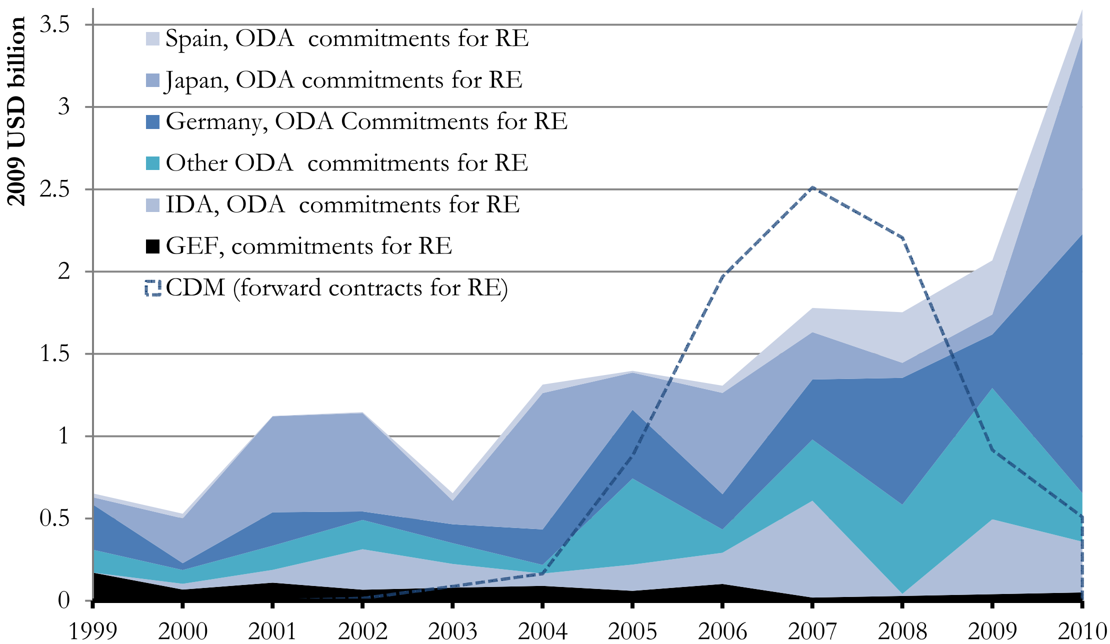
	Approved projects (until June 2009)		Committed funding (until 2009)		Disbursed funding (until end of 2008)	
	Number	%	Number	%	USD million	%
Biomass power	30	8%	141	4%	85	8%
Geothermal power	8	2%	68	2%	49	4%
Hydro power	28	7%	68	2%	31	3%
Solar power	26	7%	253	8%	130	12%
Tidal power	0	0%	0	0%	0	0%
Wind power	30	8%	164	5%	55	5%
All Renewable Power	94	24%	856	27%	356	33%
All GEF projects	393	100%	3140	100%	1090	100%

Source: database of Stadelmann (2009), based on GEF (2010d); in 2007 constant USD.

While the GEF has been the official entity of the UNFCCC's financial mechanism, most international grants to support renewable energies in developing countries have been provided by other public institutions in the last 10 years (see Figure 13). According to OECD (2011b) data around USD 0.5-2.0 billion of Official Development Assistance (ODA) has been committed to RE projects per year between 1999 and 2009. In this period, the GEF has been the second most important grant contributor among multilateral institutions, after the World Bank's International Development Association (IDA), and the fifth most important international grant contributor overall, after the IDA, Japan, Germany and Spain. While GEF's role has been substantial in the first years after the millennium, its role has diminished in the last few years while other ODA for renewable energies has substantially increased, probably connected to the rising oil price (Michaelowa and Michaelowa, 2011b), and potentially the funding pledges at the 2009 UN conference in Copenhagen. In addition, international public flows that do not meet the criteria for ODA, mainly non-concessional loans by multilateral development banks (MDBs), have supported renewable energies in the past 10 years, on average with USD 0.6 billion per year (OECD, 2012c).

Although the GEF only provides only a small part of international grants for renewable energies (see Figure 13) we will focus on GEF as an example for a public climate finance channel. There are several reasons for this; first, GEF is the only operational entity of the UNFCCC' financial mechanism that has disbursed funds for climate change mitigation[42]. Second, the GEF provides project-level documents containing CO_2 reduction estimates, which is different to other public funding institutions, so we can compare official claims for RE promotion with our results. Third, the GEF disburses funding specifically directed at climate change mitigation, while other public funds and agencies have already supported renewable energies in the 1980s and is debatable whether funding in the last 20 years is due to climate change reasons (Michaelowa and Michaelowa, 2011b). Only in the last few years, a series of non-GEF public funds dedicated to climate change have been created, both on bilateral and multilateral terms (see HBS/ODI, 2011 for a comprehensive overview). The best-funded ones are the World Bank's Climate Investment Funds (CIFs), for which donors pledged more than USD 6 billion, both in grants and loans. However, it is too early to evaluate the performance of these funds given that most of them have only disbursed funding in the last 1-2 years.

Figure 13: ODA for RE in developing countries (commitments) compared to CDM contracts



Source: OECD (2012b) for Official Development Assistance supporting renewable energies, Stadelmann (2009) for GEF, and Linacre et al. (2011) for CDM forward contract.

5.2.2 *Clean Development Mechanism (CDM) as market mechanism*

The Clean Development Mechanism has emerged as major international funding channel for RE investments in developing countries in the last ten years. The CDM is a flexible mechanism under the Kyoto Protocol (UNFCCC, 1997) that allows developed countries to partly achieve their greenhouse gas emission targets by purchasing emission reduction credits from projects in developing countries. RE has become the most important technology area for the CDM with around 65% of all registered projects and 35% of all emission reduction credits expected until the end of 2012. Until the end of 2011, more than

[42] In 2010, the Green Climate Fund was designated as second operational entity but the Green Climate Fund has not disbursed any funding until the beginning of 2013.

130 million emission reduction credits from RE projects have been issued, mostly to biomass, hydro and wind power projects (see Table 6). The corresponding financial payments can be estimated at 0.4 billion in 2010, assuming an average credit price of 10 USD[43]. While these payments are lower than the level of public grants, the actual commitment for CDM credit payments, measured by the value of signed contracts for future payments for CDM credits (Linacre et al., 2011; URC, 2011)[44], have exceeded public grant commitments in the period 2006-2008 (see Figure 13). While the level of CDM forward contracts substantially lowered in the last three years due to the economic crisis and uncertainty on post-2012 climate policy (Linacre et al., 2011), credit payments will still grow due to on-going contracts and advanced implementation of registered projects.

Apart from the CDM, voluntary carbon credits also provide financial incentives for renewable energies in developing countries, close to USD 100 million in 2011 (Peters-Stanley and Hamilton, 2012). Given the scarce data on the voluntary market, we focus here on the CDM.

Table 6: Share of renewable energy among all CDM projects (at the end of 2011)

	Registered projects		Expected credits until end of 2012		Issued credits until end of 2011	
	Number	%	million	%	million	%
Biomass energy	392	11%	168	6%	21	3%
Geothermal	12	<1%	13	<1%	2	<1%
Hydro power	1084	30%	438	16%	68	8%
Solar energy	50	1%	6	<1%	<1	<1%
Tidal power	1	<1%	1	0%	0	0%
Wind power	817	23%	333	12%	54	7%
All Renewables	2356	65%	959	35%	145	18%
All CDM projects	3620	100%	2733	100%	816	100%

Source: URC (2011)

5.3 Theoretical considerations on the effectiveness of CDM and GEF

In the following, theoretical explanations are given for why and to which extent international climate finance may influence RE diffusion. First, the different causal mechanisms of CDM's and GEF's impact on RE diffusion are explained, which are also relevant for the timing of their impact. Then, reasons are given why the effectiveness stated in official project documents may be overestimated and why this overestimation may be more relevant for one or the other of the two mechanisms. From all these steps, we derive hypotheses, which are subsequently tested in the empirical analysis.

[43] This price is based on primary credit prices reported by GIZ (2011) and the World Bank carbon market reports (Lecocq and Capoor, 2005; Capoor and Ambrosi, 2006, 2007, 2008, 2009, 2010); the average of the years 2004-2009 is taken, as primary prices should have been fixed before delivery in 2010. Euros were converted into USD using historical exchange rates from Oanda (2011).

[44] This value was estimated multiplying the USD 6-7 billion of forward contracts in this period (Linacre et al., 2011) with the share of credits from renewable energy projects in the CDM pipeline (around 35%), see URC (2011).

5.3.1 Causal mechanisms to address barriers of renewable energy diffusion

Among the key barriers of RE diffusion in the literature (Painuly, 2001; Reddy and Painuly, 2004; Brunnschweiler, 2010; Edenhofer et al., 2011) there are four that are addressed by international climate finance: higher costs of renewable energies, lack of awareness and information, regulatory barriers and imperfect financial markets.

The first barrier are higher costs of some RE technologies (Painuly, 2001; Reddy and Painuly, 2004; Edenhofer et al., 2011). Direct financial incentives provided by international climate finance can overcome this barrier, e.g. CDM credit payments can in some cases (landfill gas, specific wind and biomass power plants) cover all additional costs of renewable energies (Schneider et al., 2010). In contrast, the GEF seldom provides direct financial incentives; it rather assists countries in designing national policies that encompass financial incentives.

A second barrier for RE adoption is lack of awareness and information of investors and consumers (Reddy and Painuly, 2004; Edenhofer et al., 2011). Strategies for overcoming this barrier are e.g. education and outreach programs, which are seen as vital for success of RE deployment programs (Martinot, 1998; Bolinger et al., 2001). The CDM itself does not aim at directly providing information but it has an indirect capacity building effect via learning by-using and technology transfer (Haites et al., 2006; Schneider et al., 2008; Seres et al., 2009). In contrast, the GEF (2011c) is actively aiming at dissemination information on RE technologies, both to producers and consumers.

Third, RE diffusion is also hindered by regulatory barriers, such as no guaranteed access to the electricity grid, missing clarity of the regulatory framework (Painuly, 2001; Reddy and Painuly, 2004; Edenhofer et al., 2011) and non-reflection of externality costs in public policies (Owen, 2006). Regulatory changes or specific policies can alleviate these barriers. For example, the introduction of feed-in tariffs has led to rapid diffusion of renewable energies by guaranteeing grid access and regulating the tariff per unit of renewable electricity produced (Mitchell et al., 2006; Mendonça, 2007). While CDM does not aim at regulatory change, and has even been seen as barrier for policy adoption by some authors (He and Morse, 2010), GEF is actively initiating regulatory frameworks and policy strategies for renewable energies (GEF, 2011c).

Fourth, investment in renewable energies also rely on the availability of a well-functioning financial market (Brunnschweiler, 2010), which is linked to low macroeconomic investment risk, such as political and economic stability. CDM has not aimed at alleviating this barrier, and host country investment risks are even seen as major barrier for the CDM investment itself (Oleschak and Springer, 2007). In contrast, the GEF has tried to improve availability of capital for RE projects by setting up investment funds and strengthening financial intermediaries (GEF, 2011c).

Table 7 provides an overview of the causal mechanisms employed: while the CDM provides financial payments to cover additional costs of RE technologies, GEF is providing capacity building, advice for regulatory changes and access to capital.

Table 7: Causal mechanisms for explaining effectiveness of CDM and GEF

Causal mechanism	Expected timing of causal mechanism	CDM	GEF
Financial payments to cover additional costs of renewable energy technologies	Immediate	Used	Partly used
Capacity building to overcome information barriers of investors and consumers	Lagged		Used
Advice for setting up renewable energy promotion policies and alleviate regulatory barriers	Lagged		Used
Access to capital for overcoming imperfect financial markets and macroeconomic investment risks	Immediate		Partly used
Expected timing of causal influence		Rather immediate	Rather lagged

The use of specific causal mechanisms should have an impact of the timing of CDM and GEF effectiveness. Financial payments are expected to have an immediate effect due to the direct incentive provided, and capacity building an indirect, deferred effect on technology adoption (Jung et al., 2010). RE policies can have a direct effect on RE diffusion (Jung et al., 2010) but the GEF has only an indirect effect on policy adoption via providing advice to policy makers. Therefore, we expect that *the CDM has an immediate, positive effect on renewable energy diffusion, while the GEF has rather a lagged effect (hypothesis 1).*

Due to the causal mechanisms described above, both CDM and GEF report substantial effectiveness in promoting renewable energies. GEF estimates its own projects to reduce more than 10 million tCO_2eq per year via renewable energies, while CDM has certified GHG emission reductions of more than 70 million tCO_2eq last year (see Table 8). CDM claims higher effectiveness than GEF for all RE technologies except geothermal and solar.

In terms of effectiveness per USD of funding, GEF project documents claim 0.04 tonnes of CO_2 per USD of funding, while for the CDM no data is contained in project documents. When using 10 USD as estimate for the average payment per CDM credits (see footnote 43 for details), CDM reduces around 0.1 tCO_2eq per USD of funding by promoting renewable energies, so more than double compared to GEF. If the 10 USD per carbon credit is valid for all project types[45], CDM is more effective than GEF per USD in promoting all RE technologies except geothermal and hydro.

On average, CDM and GEF assume that renewable energies are reducing GHG emissions during a similar amount of years (see last two columns in Table 8), so numbers should be comparable in this regard.

[45] Effectiveness per USD of funding may differ between renewable technologies due to different credit prices but no reliable data on these differences is available.

Table 8: Estimated effectiveness of CDM and GEF (2007 USD)

	Effectiveness in M tCO_2eq per year (2010-2011)		Effectiveness in tCO_2eq per USD of funding		Years of GHG emissions reductions	
	GEF[1]	CDM[2]	GEF[1]	CDM[2]	GEF[1]	CDM[2]
Renewable energy	11.6	75.1	0.04	[0.10]	19	18
Biomass	3.0	4.7	0.09	[0.10]	13	17
Geothermal	4.9	1.5	0.18	[0.10]	24	21
Hydro	0.8	41.4	0.19	[0.10]	23	20
Solar	1.0	0.1	0.02	[0.10]	18	15
Wind	1.9	27.4	0.10	[0.10]	20	20

1 All values are based on a database from Stadelmann (2009), using documents from GEF (2010d). Effectiveness is based on projections of directly measurable reductions ("direct reductions") of projects registered by mid-2009. For effectiveness per USD of funding, the effectiveness values are divided by the GEF grants in 2007 USD for the respective projects; median values for each type are taken. Years of GHG emissions reductions are the reported lifetimes of technologies.
2 Effectiveness is derived from the number of CDM credits issued in the year 2011 (URC 2012), which is similar to the number of credits per year expected from projects registered by mid-2009. Effectiveness per USD of funding is not reported by the CDM documents. The number in brackets (indicating uncertainty) is the inverse of 10 USD/ tCO_2, the estimated average primary price in the years 2004-2009 (see footnote 43 for details). In these numbers, we neglect that the CDM as offset mechanism is actually replacing CO_2 reductions in industrialized countries.

5.3.2 Overestimation of effectiveness due to missing or asymmetric information

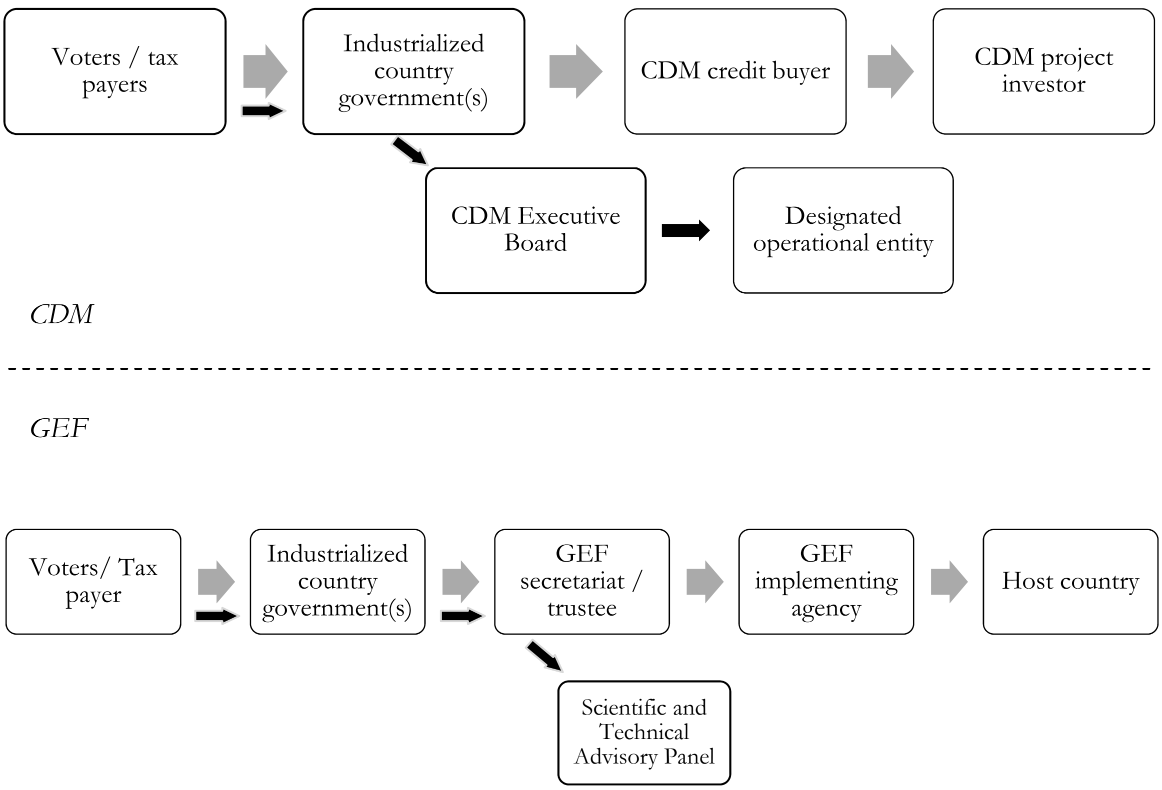
The officially[46] estimated effectiveness as cited above – both in absolute terms and relative to funding – may substantially be overestimated because of at least two reasons: non-perfect availability of information on drivers of RE diffusion at the level of project investors and developers, and asymmetric information due to incentives for investors and developers not to reveal relevant information they have.

The first reason for overestimations is that project developers may not be aware of all information on the drivers of RE diffusion, so they link the diffusion to CDM and GEF, while this diffusion may also have happened without their support because of a plethora of domestic and international drivers: Domestic drivers for RE include demand for electricity (Carley, 2009; Popp et al., 2011; Sathaye et al., 2011), energy independence (Carley, 2009; Marques et al., 2010; Popp et al., 2011), the attempt to diversify energy sources (Awerbuch and Sauter, 2006; Sathaye et al., 2011), increased economic resources for covering higher costs of RE technologies (Popp et al., 2011; Sathaye et al., 2011), the development of an advanced financial market (Brunnschweiler, 2010), increasing knowledge on RE within science, business and politics (Jacobsson and Johnson, 2000; Foxon et al., 2005; Popp et al., 2011), natural resource endowments (Carley, 2009; Edenhofer et al., 2011; Marques et al., 2011) and last but not least national RE policies (Mitchell et al., 2006; Butler and Neuhoff, 2008). Among international drivers, we find international energy prices (Marques et al., 2011; Michaelowa and Michaelowa, 2011b), development assistance and loans of MDBs (Martinot, 2001; UNEP, 2008; Kehler Siebert et al., 2010; Delina, 2011) and participation in international climate change agreements (Michaelowa and Michaelowa, 2011b; Popp et al., 2011). It is very unlikely that CDM and GEF project proponents are perfectly aware of all these drivers at the time of writing their documents. Indeed, energy market players are often found to have imperfect information (Aleem, 1990; Jaffe et al., 2005; Streimikiene et al., 2007).

46 In case of CDM, the estimated effectiveness per USD of funding is not an official estimate, as it is not only based on the official claim that each CDM credit represents one tonne of CO_2 reduced but also on non-official estimates for payments per CDM credit.

The second reason for overestimation is asymmetric information as several actors in the GEF and CDM funding chain have incentives not to display information to other actors who want to evaluate the effectiveness of GEF and CDM projects. This resembles the typical principal-agent problem (Grossman and Hart, 1983; Laffont and Martimort, 2002): A principal delegates a certain task to an agent (in our case the task is to reduce CO_2 via renewable energies), but the principal cannot fully observe the performance of the agent because the agent withholds information that is available only to him. In case of the CDM and GEF delegation chain (see Figure 14), there are many of these principal-agent relationships. The ultimate agents are the GEF project investors and the GEF host countries, who are the ones who have most information on the drivers of RE adoption. However, they have incentives not to reveal information on ineffective projects to their principals (CDM credit buyers and GEF implementing agencies), because funding is linked to effectiveness. Furthermore, these principals themselves are agents of higher order principals (governments or GEF), to whom they will not display all information either, as GEF funding and the rights to use low-cost CDM credits are linked to effectiveness. Governments themselves can be seen as agents of their voters or tax payers, to whom they may also not display all information. Therefore, it is very unlikely that the highest order principals (voters) have enough information to assess whether CDM and GEF are really promoting renewable energies, or if other drivers are relevant. This situation is similar to the multiple principal-agent problems in multilateral development funding, as identified by Vaubel (2006).

Figure 14: Delegation of mitigation (grey arrows) and project screening (thin black arrows) for CDM and GEF



Asymmetric information between principal and agents can be reduced by either trustworthy "signaling" of product quality by the agent (Spence, 1973), e.g. via guarantees and branding (Akerlof, 1970) or "screening" of product quality by the principal (Stiglitz, 1975). Screening is used in case of the CDM through the certification process: so-called Designated Operational Entities (DOEs) "screen" projects and verify emission reduction claims[47], while the CDM EB, on behalf of the countries having ratified the Kyoto Protocol, has to approve this verification and issue CDM credits. In case of the GEF, claims in the project documents are screened by the GEF secretariat, who delegates some screening work to the Scientific and Technical Advisory Panel. As both the CDM and GEF screening process itself involve delegation (see thin black arrows in Figure 14) and the screening institutions itself face asymmetric information, it seems not surprising that several studies have found that the screening is far from perfect: in case of the CDM, both DOEs and the EB have imperfect information as well (Michaelowa and Purohit, 2007; Schneider, 2009b) and DOEs even have own interests to not very thoroughly check the claims as they are paid by the investors themselves (Michaelowa, 2007a). Furthermore, EB members also have interests in low scrutiny for ineffective projects originating from their own countries (Flues et al., 2010). In case of the GEF, the assessment on emission reductions is generally found to be inconsistent and not very reliable (Eberhard et al., 2004; Stadelmann, 2009). Therefore, we can assume that screening applied in the CDM and GEF supply chain will not remove the problem of asymmetric information, so achievements may still be overestimated by the different project proponents.

Because of these two reasons, (1) the many drivers for RE that developers of CDM and GEF effectiveness may neglect in their effectiveness assessment and (2) the asymmetric information due to interests of both project developers and evaluators not to display available information on the real drivers, we can assume that *CDM and GEF effectiveness in promoting renewable energy and thereby reducing GHG emissions is lower than officially estimated (hypothesis 2).* To assess the actual effect, all drivers of renewable energy diffusion must be taken into account[48].

5.3.3 Comparative effectiveness of the two mechanisms

While we have set the hypotheses that GEF and CDM are effective in reducing CO_2 via renewable energies but overestimate their contribution, a further question is: which one of the two mechanisms is comparatively more effective per USD of funding? This may be important information to allocate the USD 100 billion funding pledged in Copenhagen 2009 (UNFCCC, 2009b). As documented above (Table 8), according to official numbers, the CDM is more effective per USD of funding, except for hydro and geothermal power (assuming a credit price of 10 USD).

The question is whether the higher effectiveness of CDM holds if we take into account the just discussed overestimation due to neglecting relevant drivers for RE, which can happen both because of information that project developers are missing (e.g. whether upcoming policy change will enable or disenable investments) or information that is not revealed by some actors. Overestimations due to generally missing information seems to be more likely in case of the GEF as ex-ante calculation and verification of CO_2 reductions are not well elaborated (Eberhard et al., 2004; Stadelmann, 2009), and evaluating GEF' impacts through measures such as capacity building and support for regulatory change involves high uncertainty (Mee et al., 2008). Overestimations due to information not revealed by some actors could be more pronounced for either GEF or for CDM. On the one hand, GEF project developers or implementing agencies may find it less difficult to disclose information on GHG emissions reductions, as project documents are less thoroughly checked and funding is not directly conditional on GHG emissions reductions. On the other hand, CDM project developers have clear financial incentives

[47] Certification of emission reductions can also be seen as "signal" of project owners to buyers that their projects actually reduce emissions.

[48] Unfortunately, with the empirical strategy used, it will not be possible to assess whether drivers are non-intentionally (reason 1) or intentionally (reason 2) not taken into account. For assessing this, expert interviews would be needed.

to hide information (e.g. that some of the projects are BAU) as CDM funding is directly linked to CO_2 emission reductions. Furthermore, several overestimations have not been detected leading to some BAU projects being approved for CDM support (Michaelowa and Purohit, 2007; Haya, 2009; Schneider, 2009b).

Summing up, there is a lower chance of overestimation in the CDM due to generally missing information given the more elaborated GHG accounting methodologies but we can theoretically not be sure whether overestimation due to non-revealed information, is more pronounced in case of GEF or CDM. Given this uncertainty on overestimation, it can be assumed that the estimates of the funding institutions hold that, *in case of biomass, solar and wind power, the CDM is more effective than the GEF per USD of funding in promoting renewable energies, while in case of geothermal and hydro, the GEF is more effective (Hypothesis 3).*

5.4 Empirical strategy and models

We will test these hypotheses by using macro level panel models estimating the determinants of RE diffusion in different developing countries. There are several reasons for using macro (country level) rather than micro (project level) data. First, effectiveness of CDM funding has already been examined on the micro level (Michaelowa and Purohit, 2007; Haya, 2009; Schneider, 2009b), so a comparison with macro level methods may provide interesting insight. Second, micro level data analysis on effectiveness of climate finance suffers the same problem that haunts CDM verifiers: what would happen in the absence of climate finance? Only the project owner will know the probable answer as the situation without climate finance is a counterfactual situation. Using macro level data, we can try to approximate the counterfactual situation of a country by comparing it with very similar countries and with the same country in different years. In contrast, micro level data on "very similar" projects without CDM and GEF funding is not available. Third, some of our hypotheses can only be tested on a macro level, e.g. the overestimation due to neglecting the influence of macro level drivers of diffusion.

Equation 1 shows the basic model we use. The dependent variable is RE_{it}, the CO_2 reductions emerging from renewable electricity production[49] in country i and year t. The main independent variables are GEF_{it}, the GEF payments received by a country, and CDM_{it} the expected future income from registered CDM projects. $\boldsymbol{X_{it}}$ is representing the control variables and u_{it} the error term. The coefficients α_1 and α_2 are estimating the impact of GEF and CDM on RE diffusion and can, therefore, be used to test hypothesis 1 (positive impact), hypothesis 2 (lower impact of GEF and CDM when comparing coefficients of models controlling for all drivers – represented by the matrix $\boldsymbol{\beta' * X_{it}}$ – with officially estimated effectiveness or model coefficients when not controlling for these drivers) and hypothesis 3 (higher effectiveness per USD of CDM compared to GEF funding, for biomass, wind and solar). Given that RE production may largely depend on the last year's production, we include the lagged dependent variable $L.RE_{it}$ as independent variable.

$$RE_{it} = \alpha_0 + \alpha_1 * GEF_{it} + \alpha_2 * CDM_{it} + \boldsymbol{\beta' * X_{it}} + \gamma * L.RE_{it} + u_{it} \quad (1)$$

[49] While the installed capacity of renewable energies would be less sensitive to annual changes in natural resources (biomass, wind, solar), there are several disadvantages of using installed capacity: First, installed capacity itself does not guarantee electricity production and CO_2 reductions; the effectiveness of CDM RE projects has often been overestimated in ex-ante calculations (Castro and Michaelowa, 2008). Second, without production data, no CO_2 reductions can be estimated. Third, data for installed capacities in developing countries are only available for 5 years (2005-2009), so we would lose many observations.

5.4.1 *Two-step estimation strategy*

As our dependent variable is censored – it has no negative values but many zeros (as many developing countries do not produce RE-based electricity at all) – the use of all data in standard models for continuous variables (e.g. ordinary least square with fixed effects) would result in biased results. The more appropriate model for such censored data is the Tobit model but the later does not accurately model situations where some coefficients may have different signs in selection and regression equation (Greene, 2008: 877). Furthermore, country fixed effects cannot be included. We will, therefore, use a two-step estimation strategy as suggested by Wooldridge (2009: 595) for such cases.

The first step is a selection (or adoption) model analyzing the determinants of whether countries produce renewable electricity (coded as 1) or not (coded as 0). For such a binary dataset, a Logit model is well suited, as it takes the boundaries of the dataset into account.

As second step, we apply models for continuous variables only using data from countries where RE is present. Among such models, we use fixed-effects and random-effects models (Wooldridge, 2010) and compare the results with Arellano and Bond (1991) and Blundell and Bond (1998) Generalized Methods of Moments (GMM) models to correct for bias due to potentially endogenous variables. These diffusion models are now further explained.

5.4.2 *Fixed and random effects models*

Compared to cross-sectional data, panel data allows us to correct our estimates for country fixed-effects (FE) on RE diffusion. For this purpose we include dummies for each country, which equals deducting the country mean value from the dependent variable and all determinants (see equation 2). The coefficients are then estimated with OLS regressions.

$$RE_{it} - \overline{RE}_i = \alpha_0 + \alpha_1(GEF_{it} - \overline{GEF}_i) + \alpha_2(CDM_{it} - \overline{CDM}_i) + \boldsymbol{\beta}(\boldsymbol{X_{it}} - \overline{\boldsymbol{X}}_i) + \gamma\,(L.RE_{it} - L.\overline{RE}_i) + u_{it} - \overline{u}_i \quad (2)$$

Additionally, we estimate random effects generalized least square models, which should result in more efficient estimations than fixed effects models as both between and within country variation are used. Estimators from random effect models can be inconsistent, so the Hausman test (Greene, 2008: 209) is used to test consistency of random-effects when compared to fixed-effects estimators.

5.4.3 *Generalized methods of moments (GMM) models*

Apart from the standard panel models – fixed and random effects – we will also specify Generalized Methods of Moments (GMM) models, which allow for correcting biased estimates if the lagged dependent variable is an important predictor (dynamic panel setting) and some other independent variables are not strictly exogenous.

In our case, the lagged dependent variable – the past level of RE diffusion – may be a particularly powerful predictor as RE installations have a lifetime of more than 10-20 years, and past adoption of RE may drive knowledge, networks and institutions (Jacobsson and Johnson, 2000), thereby even further promoting renewable energies. Simply including the lagged dependent variable in standard fixed effects models will not solve the problem of biased estimators as the lagged dependent variable is by definition endogenous (correlated with the error term), and the coefficient of the lagged dependent variable will be downward biased. Using ordinary least square model with clustered standard errors is also not a solution as it would result in upward biased estimates of the lagged dependent variable (Bond, 2002).

Beside bias in the lagged dependent variable, dynamic panel models may also result in other biased coefficients, which would affect our estimates of GEF and CDM effectiveness. Even if results of Monte Carlo simulations suggest that bias of these coefficients should be less pronounced than bias of the lagged dependent variable (Judson and Owen, 1999), we may have to care about potential bias on coefficients of CDM and GEF because these variables may be partly endogenous on their own: both CDM and GEF funding may target countries where substantial diffusion is expected.

An often used way to address endogeneity of variables is to use instrumental variables in regression models. However, finding good instrumental variables is very difficult as they should be exogenous, highly correlated with and influencing the endogenous variable but have no direct effect on the dependent variable. In case of dynamic panel models, Anderson and Hsiao (1982) proposed to use a differenced model (see equation 3) to both remove fixed effects and use the second lagged dependent variable (in our case RE_{it-2}) as instrument. As RE_{it-2} may alone not be strongly correlated with ΔRE_{it-1} even deeper lags may be useful, but one data year is lost per further lag used as an instrument, substantially lowering our sample size.

$$\Delta RE_{it} = \alpha_0 + \alpha_1 * \Delta GEF_{it} + \alpha_2 * \Delta CDM_{it} + \boldsymbol{\beta} * \Delta \boldsymbol{X_{it}} + \gamma * L.\Delta RE_{it-1} + e_{it} - \bar{e}_i \quad (3)$$

Arellano and Bond (1991) suggested to use a GMM differenced model (with lagged instruments) that performs better than the Anderson-Hsiao model in Monte-Carlo simulations[50], and allows to use a different set of instruments for each period, and thereby less observations have to be dropped (Roodman, 2006)[51]. These instruments are assumed to be not correlated with the errors, which is equal to the so-called "moment conditions". The minimization of these moment conditions is then the basis of the GMM estimators. Whether the instruments are jointly valid, meaning that they are not correlated with the errors, can be tested with a Sargant or Hansen chi-square test.

In our case, GMM framework is not only useful to instrument the endogenous lagged variable but also to instrument other variables that are endogenous, i.e. correlated with present errors, or predetermined, i.e. independent of current errors but not strictly exogenous as correlated with past errors (Roodman, 2006). Such endogenous or predetermined variables are, for example, GEF and CDM funding as they may be influenced by past or projected levels of renewable energies. A further advantage of Arellano Bond GMM estimators is that they are well suited for panels with few periods and many countries (Roodman, 2006), corresponding to our dataset.

Unfortunately, Arellano-Bond difference GMM performs quite poorly if the development of the dependent variable is close to a random walk, i.e. changes in the dependent variable are random. In such cases, lagged instruments contain little information. We may face this problem particularly when

[50] According to Monte-Carlo simulations by Judson and Owen (1999), who compare bias in different dynamic panel models, GMM models are preferable to FE models, and preferable or equal to Anderson-Hsiao models if T≤20, which is the case for our dataset. Judson and Owen (1999) also find that a corrected FE dynamic panel model according to Kiviet (1995) is preferable to GMM if the panel is balanced, which is not the case here, as we only use positive values, so some years are dropped for some countries. Bruno (2005) developed a corrected FE estimator for unbalanced panels but the related Stata command (xtlsdvc) lacks important test statistics and standard error options. When using Bruno's corrected FE estimator, the coefficient results (see Annex 10.2) did not differ substantially compared to the GMM results presented in the following.

[51] The idea of using different sets of instruments for each period was already proposed by Holtz-Eakin et al. (1988).

analyzing hydro and geothermal power, where large plants have been built before our sample starts, and no subsequent changes occur. To address this problem of hardly (i.e. only randomly) changing dependent variables, Blundell and Bond (1998) have proposed to use not only difference but also levels equations for GMM estimations. By also using level equations, differenced lags can be used as further instruments. This system GMM estimator makes a further assumption: the differenced lags have to be uncorrelated with errors, which implies that the initial value for the dependent variable has to be in stationary equilibrium, i.e. the initial values' deviation from the long-term convergent values has to be uncorrelated with the fixed effects. This initial stationarity condition is, in cases where all countries have a common starting point for renewable energies, equal to stationarity at the start of the study period (Roodman, 2009). Such stationarity at the panel start should be given in case of hydro and geothermal power where the levels of power production are already substantially determined at the start of the panel, while this condition is not clearly given in case of solar and wind power that had not yet substantially diffused at the start of the study period. However, we will see that Arellano-Bond models for solar and wind power, which do not require stationary equilibrium, are showing similar results than Blundell Bond models.

We use Rodman's (2006) xtabond2 STATA command to estimate both Arellano and Bond's difference and Blundell and Bond's system GMM[52]. Apart from marking GEF and CDM as endogenous, we will also include time dummies to make the GMM models assumption of no correlation across countries more likely (Roodman, 2006).

5.5 Operationalization of variables and data

We use a data set covering 122 developing countries and 19 years (1991 to 2009), which corresponds to the period when GEF (since 1991) and CDM (since 2005) have been operational. In this section, we describe the operationalization of the dependent, the independent and control variables, including data sources. In order to assure comparability, variables containing financial values have been transformed to 2007 constant USD, using deflators from the OECD (2010b).

5.5.1 Dependent variable: CO_2 reductions via renewable energy diffusion

As dependent variable, we use the annual grid-based RE production, measured in gigawatt hours (GWh), using data from the US Energy Information Administration (EIA, 2010). The grid-based production is split into biomass and waste, geothermal, hydro, wind and solar energy production. In order to understand the related effect on CO_2 emissions, we multiply each GWh of grid-based RE production with 500 tonnes of CO_2, the average emission intensity in developing world in the panel period according to IEA (2009b). Using such a standard CO_2 factor for each unit of electricity can be justified because of the growing globalization of fossil fuel markets (Neumann, 2009; Li et al., 2010), which levels out deviation in CO_2 intensities of power production. The standard CO_2 factor has two further advantages: first, our dataset is not diminished by missing data on grid factors for some countries and second, each tonne of CO_2 represents an equal amount of RE production, so that we can compare our results with the literature on RE diffusion. As disadvantage, it is less precise than country-specific CO_2 factors, so we show models using country-specific CO_2 factors (average over the period) in the Annexes 10.2.3-10.2.7. To take into account the size of countries, we divide all values by the Gross Domestic Product (GDP) in USD million.

[52] For BB estimations, we use the specification for matrix H (the initial estimate of the variance of errors) as used in Arellano-Bond's own statistical package (Dornik et al., 2001).

As sensitivity analysis, we also estimated models using CO_2 reduction via RE electricity production per capita and RE as percentage of total electricity production as dependent variables. Results for these alternative models are only shown in the Annex (10.2.3-10.2.7) and differences to the results of the basic model will be noted in the following. We can expect more conservative results on effectiveness if RE is divided per GDP or the overall electricity production, as RE production mainly increases with GDP and overall electricity production, and less with a raising population[53].

5.5.2 Independent variables: CDM and GEF

CDM: our variable is the expected value of future CDM credits from RE projects registered by the CDM in the respective year. The expected credits are the ones claimed in project design documents, as collected by URC (2011), the most used database for CDM projects. Only expected credits until 2012 are included, as credit purchases after 2012 have been highly uncertain (see post-2012 prices in GTZ, 2010; GIZ, 2011); modeling results with post-2012 are shown in the Annex (10.2.3-10.2.7). The expected credits are adjusted in several ways: credits for off-grid renewable energies, for heat production and methane avoidance are subtracted, in order to have a precise measure for credits related to grid-based renewable electricity production. The number of expected credits at registration is also corrected for the percentage of expected credits that is really issued per project, again using data from URC (2011). These expected credits are multiplied with USD 10 as credit price estimate (see footnote 43 for details)[54]. For the models, we sum up the expected credit value of projects registered in the three previous years into one variable, as the different lags heavily correlate. We use only lags as it takes at least one year from the investment decision, which is not taken before CDM registration if CDM funding is really vital, and the start of electricity production, given that the construction time of RE power plants takes several months in case of solar and wind (First Solar, 2012; Wind Energy Facts, 2012) and even more than 1-2 years in case of advanced biomass, geothermal and hydro power (Lesser, 1994; Faaij et al., 1997; Mbohwa and Fukuda, 2003; Rangel, 2008). Using even deeper lags (four years ago an earlier) is not meaningful as the first CDM projects have only been registered in 2005. As sensitivity analysis, we estimated the impact of different CDM lags, see Annexes 10.2.3-10.2.7.

GEF: the variable contains GEF grants for the different RE technologies. Grant numbers are taken from a database compiled by Stadelmann (2009) using official information from the GEF project management information system, a GEF internal database system that entails further information than the GEF internet database (GEF, 2010d). Only funding related to grid-based renewable energies is included and funding for biomass, geothermal, hydro, solar and wind is separated. The funding is adjusted to real disbursement until the end of 2008, using a document by the World Bank as GEF trustee (GEF, 2009c). As the year of real disbursement is not known, the grant numbers are allocated to the year of GEF CEO endorsement, which is closer to the real disbursement than the GEF Council approval[55]. For measuring the whole effect of GEF, we sum the 1st to 9th lag of GEF commitments in the standard model[56]. To allow for distinguishing short from long term effects, we also specify alternative models (see

[53] This theoretical assumption is confirmed by our database that shows a correlation of 0.82 between RE electricity production and both GDP and total electricity production, while the correlation is only 0.65 between RE electricity and population.

[54] The credit price assumed here is only important when comparing CDM with GEF effectiveness. When comparing official claims for CDM with estimates of our models, the assumed credit price does not matter, as the same credit price is assumed for both official and the model estimates.

[55] In cases where the endorsement year is not known, a distance of 1.4 years between GEF council approval and CEO endorsement is assumed, which is the average distance of approval and endorsement (Stadelmann, 2009). In case of the few mid-size projects (below USD 1 million of funding), CEO approval is taken as funding year, as endorsement is not needed.

[56] The use of these deep lags does not affect the number of observations, as we have observations for this variable that are much older than the period we are analyzing.

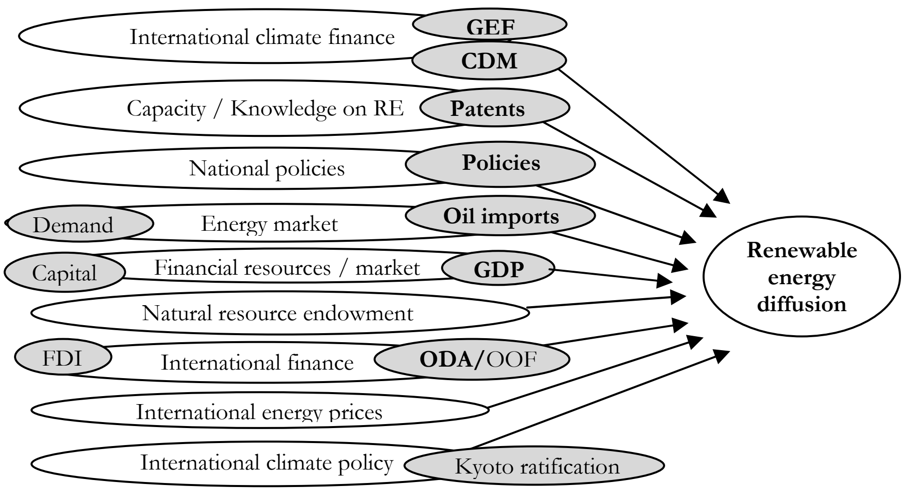
Annex) where the 1st to 3rd lag are clustered, representing the immediate effect, while the 4th to 6th lag and the 7th to 9th lag are clustered, representing the longer term effects.

To take into account the size of countries, we divide all CDM and GEF funding by the Gross Domestic Product (GDP) in USD million. Therefore, we have the same standardization as in case of the dependent variable, and we can therefore state an expectation for the GEF and CDM coefficients. If we assume that 1 tCO_2 can be reduced for 10 USD, and that new RE installations will last for about 20 years, we can expect GEF and CDM coefficients of roughly 0.005 in the following models.

5.5.3 Control variables: other drivers for renewable energy diffusion

The control variables are particularly relevant for testing hypothesis 2 (reduced effectiveness of GEF and CDM when other drivers are taken into account). For identifying the most important drivers for RE diffusion, we reviewed the literature, particularly focusing on quantitative studies in industrialized countries (Carley, 2009; Marques et al., 2010; Popp et al., 2011) and literature reviews (Sims et al., 2007; Mitchell et al., 2011). Based on this, we derived the drivers of RE as shown in Figure 15, which will be explained in the following. For all control variables, we use the first lags (if not noted differently) as changes in electricity production will depend on investment decisions undertaken in the past; we can expect around 0.5-1.5 years delay between investment decision and production, see the section on GEF and CDM.

Figure 15: Modeling renewable energy diffusion: potential drivers



Knowledge: Creating knowledge has been identified as a key function of socio-technical systems in general (Hekkert et al., 2007) and of systems promoting renewable energies in particular (Jacobsson and Johnson, 2000; Foxon et al., 2005). Popp et al. (2011) have found, based on data of international patents of RE technologies that knowledge on renewable energies has a significant influence on RE diffusion in OECD countries. To control for the RE knowledge in a country we include a knowledge variable, based on the number of patents a country filed under the international Patent Cooperation Treaty, whereas patents are allocated to the residence country of the applicant and to the year of the priority data, which corresponds to the first filing worldwide and is therefore closest to the invention date (OECD, 2012a).

The knowledge stock (KS) of country *i* in year *t* is calculated with the same formula (4) as used by Popp et al. (2011), which assumes that knowledge in patents both diffuse and decay over time. For standardization, we divide knowledge stock by the population in million inhabitants.

$$KS_{i,t} = \sum_{l=0}^{\infty} e^{-DEC(l)}(1 - e^{-DIF(l+1)})Patents_{t-l} \qquad (4)$$

As Popp et al. (2011), we assume a decay rate (DEC) of 10% and a diffusion rate (DIF) of 25% per year. Data for PCT patent filing per country and RE technology was taken from the OECD (2012a) for the period 1980-2009. For the biomass knowledge stock we used patents on biomass waste energy and biofuels, for hydropower the ones on conventional and new hydro power, and for solar the ones of solar PV and solar thermal. Given the period restriction of our patent data, the summing in formula (4) does not go back to infinity but only to the year 1980, so e.g. l=20 in case of the year 2000. In one of the sensitivity analyzes (see annexes 10.2.3-10.2.7), we replaced our patent stock variable with the tertiary education gross enrolment rate (% of age-group), using intra- and extrapolations from World Bank (2012) data.

Domestic policies: National RE policies have been decisive for the diffusion of renewable energies in OECD countries (Mitchell et al., 2006; Butler and Neuhoff, 2008; Johnstone et al., 2010; Dong, 2012) and, even when the design is considered to be improvable, also in China (Cherni and Kentish, 2007; Wang et al., 2010). All RE policies existing in a country are summed up, using data from a database by IEA (2010c), complemented with information from REN21 (2011b) and REEEP (2011). In order to capture the impact of new policies, our RE policy variable, different for each technology, entails the number of three previous years, in which a new policy has been adopted. In the sensitivity analysis, we use the total number of policies in the previous year as alternative specification, while we also analyze the impact of technology-unspecific RE policies and dominant types of policies (see Annex 10.2.3-10.2.7)[57]. Using the policy change terminology of Knill et al. (2012), our policy variable measures the density of regulation (number of policies) but due to missing data not the intensity (e.g. tightness of standards or level of feed-in tariff).

Domestic energy market drivers: The increased use of electricity in many developing countries is considered a major driver for renewable energies (Carley, 2009; Popp et al., 2011; Sathaye et al., 2011). We, therefore, include the electricity consumption as control variable, using data from EIA. Another phenomenon promoting renewable energies is dependence on foreign energy sources (Carley, 2009; Marques et al., 2010; Popp et al., 2011). Thus we control for the net oil imports in thousands barrels a day (exports are deducted) as proxy of energy dependence, divided by the oil consumption for standardization, using data from EIA (2010). In the sensitivity analysis, we have tested for the influence of other energy market drivers such as the share of hydro power in the grid and grid losses as proxies for the flexibility and stability of the electricity grid, which are both important for renewable energies (Sims et al., 2011).

Domestic financial resources and financial market: Economic resources are relevant for covering higher costs of renewable energies and may indirectly drive renewables via energy market growth (Popp et al., 2011; Sathaye et al., 2011), so we include the GDP per capita as control, using data from the World Bank (2011). Apart from economic resources in general, the development of a well-functioning financial market has been detected as important determinant of RE diffusion (Brunnschweiler, 2010). Among the

[57] In general, technology-specific policies have a positive effect (although only significant in case of wind power) while technology-unspecific RE policies had not. Among different types of policies, financial incentives had the largest effect in case of biomass, geothermal and solar, portfolio standards in case of hydro, and tenders in case of wind (see Annex 10.2.3-10.2.7).

three indicators for financial market development used by Brunnschweiler, we use the amount of liquid liabilities as a percentage of GDP, as the other indicators would substantially lower our sample[58]. Liquid liabilities are a broad measure for financial depth; it includes all banks and bank-like and nonbank financial institutions and is defined as "currency plus demand and interest-bearing liabilities of banks and other financial intermediaries to GDP" (Beck et al., 2009: 4). The information on liquid liabilities is taken from a dataset of Beck et al. (2009).

Natural resources: endowment with natural resources is seen as an important variable influencing RE diffusion (Edenhofer et al., 2011) and, therefore, most quantitative analyzes on RE control for it (e.g. Carley, 2009; Castro, 2011; Marques et al., 2011). We control for the natural resources needed for renewable power production using different variables for each type of RE. Biomass resources are approximated with annual roundwood production in m^3 per capita (FAO, 2012), geothermal resources with the number of volcanoes per km^2 as indicator for geothermal activity (Smithsonian Institution, 2011), hydropower resources with the average rainfall in the relevant period (DWD/WZN, 2010) times average elevation of the country (Gallup et al., 2001), solar resources with the latitude tilt radiation in $kWh/m^2/day$, and wind resources with the average wind speed in m/s in the years 1983-2005 (NASA, 2011). The original hydro, solar and wind data was pixel-based with a precision of 1 degree (geographical coordinates); the variables were created by allocating each pixel to countries (using Google maps coordinates) and averaging the hydro, solar and wind data in the pixels allocated to the respective country. In the sensitivity analyzes (see annexes 10.2.3-10.2.7), we have included alternative or additional resource variables, such as agricultural area in km^2 per capita for biomass, absolute number of volcanoes for geothermal, altitude as well as present and last year rainfall for hydro (essentially splitting our variables into different parts), horizontal irradiation for solar and percentage of time wind speed is above 6m/s for wind power.

International financial resources: Among public international finance, both bilateral development assistance and loans of bilateral and multilateral development banks have substantially supported renewable energies over the past 20 years (Martinot, 2001; UNEP, 2008; Kehler Siebert et al., 2010; Delina, 2011; Michaelowa and Michaelowa, 2011b). For ODA, we control for commitments for the support of renewable energies, using data from Michaelowa et al. (2010), which is based on a review of information reported to the OECD (2011b). For development bank loans, we use OECD (2011b) data on commitments for other official flows (OOF) supporting RE. This latter variable is only used for sensitivity analysis and not in the main model, as OOF data on renewable energies only goes back to 1995 and therefore substantially reduces the sample size. The 1^{st} to 9^{th} lags are taken together for the ODA variable, and only 1^{st} to 3^{rd} lags for the OOF in order not to lose even more observations. These values are divided by the GDP in USD billions for comparability.

International energy prices*:* international energy prices, particularly the oil price are an often cited driver for renewable energies (Marques et al., 2011; Michaelowa and Michaelowa, 2011b). Therefore, we could use the Europe Brent Spot Price for crude oil in USD per barrel from EIA (2011) to control for international energy prices. However, as the oil price in our data is only changing over time but not across countries, we do not have include the oil price as time dummies already control for the oil price. To see whether the oil price has an impact, it is only included in one of the alternative analyses, see annexes 10.2.3-10.2.7.

International agreements: industrialized countries have been prompted to invest in renewable energies due to participation in international climate change agreements, such as the Kyoto Protocol (Popp et al.,

[58] Using such a smaller sample, we also tested whether private credit by deposit money bank as % of GDP (Beck et al., 2009) influences RE diffusion but this variable had no influence on any of the five renewable energy types.

2011). As developing countries have no legally binding obligation to reduce CO_2 emissions, the UNFCCC and the Kyoto Protocol should primarily have an indirect influence via the GEF and the CDM. Nevertheless, we include the years since Kyoto Protocol ratification as additional control variable in one of the sensitivity analyzes to see whether there is an influence beyond GEF and CDM.

The summary descriptions for all variables can be found in Table 9, while summary statistics are provided in Annex 10.2.1. GDP and electricity demand are highly correlated (see correlation table in Annex 10.2.2), so only GDP is included in the basic models, while electricity demand is replacing GDP in one of the sensitivity analyses (see Annexes 10.2.3-10.2.7). As liquid liabilities reduce the sample size, we also use this variable only in one of the sensitivity analyses.

Table 9: Summary descriptions of variables

Function	Variable	Unit	Description	Sign[1]	Sources
Dependent variable	Renewable electricity	tCO_2 per USD	Grid-based renewable electricity production, multiplied with 500 tCO_2 per GWh as average grid factor, see IEA (2009b), per million USD of GDP		EIA(2010)
Independent variable	CDM	ppm	Expected CDM payments until 2012, in USD, for projects registered in lags 1 to 3, corrected for issuance success, assuming USD 10 per credit, for each RE technology, per million USD of GDP	+	URC (2011)
	GEF	ppm	GEF grants that are CEO approved or endorsed, in USD, for each RE, per million USD of GDP, lags 1 to 9	+	World Bank (2011), Stadelmann (2009)
Control variables in standard model	Knowledge	#	Knowledge stock due to past and current patents, for each RE technology, per million inhabitants, last year	+	Based on data from OECD (2012a)
	Policies	#	Number of 3 previous years with additional RE policies, for each technology	+	IEA (2010c), REN21(2011b) & REEEP(2011)
	Oil imports	%	Daily imports minus exports of crude and refined oil in barrels, in % of oil consumed, last year	+	EIA(2010)
	GDP per capita	k USD/ p.c.	Gross domestic product in USD per capita, last year	+	World Bank (2011)
	Biomass resources	m^3/p.c.	Annual roundwood production in m^3 per capita	+	FAO (2012)
	Geothermal resources	k #/km^2	Thousands volcanoes in the country per km^2	+	Smithsonian Institution (2011)
	Hydro resources	m^4	Rainfall (average over country area) * average elevation, level and last year	+	DWD/WZN (2010), Gallup et al. (2001)
	Solar resources	kWh/ m^2/day	Latitude tilt radiation in kWh/m^2/day (average over country area) in years 1983-2005	+	NASA(2011)
	Wind resources	m/s	Average wind speed (average over country area) in years 1983-2005	+	NASA(2011)
	ODA	ppb	Official development assistance commitments in lags 1to9, in USD, for each RE technology, per billion USD of GDP	+	Michaelowa and Michaelowa (2010)
Additional control variables for sensitivity analysis	Kyoto Protocol	Years	Years since ratification of Kyoto Protocol, last year	+	UNFCCC(2011c)
	Electricity use	GWh per capita.	Total electricity consumed per capita, last year	+	EIA(2010)
	Financial market	%	Liquid liabilities in percentage of GDP, last year	+	Beck et al. (2009)
	Develop-ment loans	ppm	Other official flow commitments for RE, per million USD of GDP, lags 1 to 3	+	OECD (2011b)
	Policies (measure 2)	#	Number of RE policies, for each technology, last year	+	IEA (2010c), REN21 (2011b) & REEEP(2011)
	Oil price	USD per barrel	Europe Brent Spot Price for crude oil in USD per barrel, last year	+	EIA (2011)
	Grid stability	%	% of hydro power in the grid	+	EIA (2011)

[1] Expected sign of the coefficient

k = 1000, M = million, p.c. = per capita, ppm = parts per million, ppb = parts per billion, RE = renewable energy, USD = 2007 constant USD

5.6 Results

In the following, the estimation results are presented. For each type of RE, four estimates are shown. First, the results for the Logit selection model with clustered standard error, to see if GEF and CDM have an influence on whether the decision of countries to use renewable energies or not[59]. Second, results for three different models using only cases with positive dependent variables;

(1) Models with country fixed or random effects controlling for all covariates, and using robust standard errors. The random effects model is shown if the Hausman test suggests that it is consistent; otherwise the fixed effects model is presented.

(2) Estimations from a Blundell-Bond (BB) one-step GMM system model, also controlling for all covariates. In the version presented below, CDM, GEF, ODA and policies are assumed to be endogenous, so they are instrumented like the lagged dependent variables. The same coefficients are significant (and the coefficient are similar) when assuming exogeneity of all independent variables (except the lagged dependent variables), see annexes 10.2.3-10.2.7. In the same annexes, the results for the Arellano Bond models can be found, which are less convincing than the BB results as the coefficient of the lagged dependent variable is not always between the coefficient of the OLS estimators[60], which tends to be upward biased (Bond, 2002), and the fixed effects estimators, which tend to be downward biased (Nickell, 1981; Bond, 2002: 144). In all BB models, there is no evidence for remaining first-order autocorrelation and the Hansen test suggest that the instruments are jointly valid (except for some biomass and hydro power specifications). Unfortunately, the Hansen test is weakened by the high number of instrumental variables used (Roodman, 2006)[61].

(3) BB one-step GMM system model with only GEF and CDM and the lagged dependent variable as covariates are shown in order to approximate the assessment of GEF and CDM effectiveness before any control. Only the lagged dependent variable is instrumented, as policy makers can be assumed to not reflect on endogeneity in their assessment.

For BB models, all of the following sensitivity analysis did not substantially change the results for CDM and GEF: tertiary education, alternative variables for natural resources, inclusion of Kyoto ratification, electricity demand, liquid liabilities and other official flows as control variables, different variables for GEF, CDM and policy influence, see annexes 10.2.3-10.2.7.

[59] These models exclude fixed effects and the lagged dependent variable, as most observations would be lost when including them, given that there are hardly any changes from 0 to 1 within a country.

[60] The OLS estimators with full control variables, including the lagged dependent variable are presented in the annexes 10.2.3-10.2.7.

[61] The validity of the Hansen test can be improved by reducing the instruments below the number of panels (Roodman, 2006). In our case, models with fewer instruments do not produce convincing results, as the coefficients on the lagged dependent variable move out of the credible range.

5.6.1 Biomass power

Results in Table 10 show that CDM funding has a significant influence on both presence and diffusion of biomass power. The CDM impact also remains stable if we model RE production per capita or use the real grid factor model, although the coefficient is lower in case of the per capita model. In contrast, GEF has no significant and clearly a lower impact than CDM funding, corresponding to our hypothesis. From the other covariates, ODA has a significant impact in the fixed effect models, and natural resources have a significant impact in the BB model.

Table 10: CDM/GEF effectiveness in reducing CO_2 via biomass power

	Logit selection model, clustered SE		Fixed effects model, robust SE		Blundell-Bond GMM system model, one step, robust SE		Blundell-Bond GMM system model, one step, robust SE	
	dy/dx	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Lagged DV			0.650	(0.139) ***	0.715	(0.152) ***	0.627	(0.210) ***
CDM	0.017	(0.010) *	0.018	(0.004) ***	0.017	(0.005) ***	0.020	(0.006) ***
GEF	-0.000	(0.000)	0.002	(0.003)	-0.001	(0.001)	-0.003	(0.003)
Knowledge	5.636	(6.377)	-2.848	(4.110)	-5.809	(5.255)		
Policies	0.043	(0.074)	0.368	(0.418)	0.348	(0.494)		
Oil imports	0.005	(0.007)	-0.055	(0.060)	0.075	(0.027)		
GDP per capita	0.015	(0.010)	-0.044	(0.082)	-0.055	(0.039)		
Nat. resources	0.031	(0.040)	0.795	(0.866)	0.602	(0.236) **		
ODA	-0.000	(0.001)	0.655	(0.252) **	0.461	(0.289)		
Constant			0.453	(0.954)	0.175	(0.481)	0.651	(0.482)
Year FE	Yes		Yes		Yes		Yes	
N	2182		503		503		503	
Groups	133		36		36		36	
Wald-test	0.00	(Wald, p-value)	0.00	(Wald, p-value)	0.00	(Wald, p-value)	0.00	(Wald, p-v.)
Various stat.	0.08	(Pseudo-R^2)	0.84	(R^2)	0.96	(AR2, p-value)	0.99	(AR2, p-v.)
Hansen test					0.00	(p-value)	1.00	
# instruments					403		199	
Endogenous variables	-		-		CDM, GEF, ODA, policies		-	

Dependent variable: tonnes of CO_2 reduced with biomass power generation, per million USD of GDP (2007 USD), assuming 500 tCO_2 reduced per GWh of renewable power production
Significance levels: * = p-value of coefficient <0.1, ** = p-value <0.05, *** = p-value <0.01
Consistent with theory, the Blundell Bond coefficient for the lagged dependent variable is between 0.650 (fixed effects coefficient) and 0.941(coefficient of OLS model with control variables, see annex)

5.6.2 Geothermal power

CDM has a significant influence on diffusion of geothermal power in the random effects model but not in the full BB model (see Table 11). However, in some of the alternative specifications in the sensitivity analysis, the CDM coefficient becomes significant. GEF has both an effect on selection and diffusion, and the significance of the impact is not sensitive to alternative BB specifications (see Annex 10.2.4). GEF's has an impact in the short- and mid-term (1 to 6 years after GEF funding approval), while no long-term impact (7 to 9 years) could be found, see Annex 10.2.4. Still, GEF's impact is not completely robust as the coefficient becomes insignificant if we are modeling geothermal power per capita instead of per GDP. Therefore, CDM and GEF may have an impact on diffusion of RE but in both cases, the significance of the impact depends on the model specification.

Among, the other covariates oil imports have a significant impact in the selection model, while natural resources as well as ODA promote diffusion of geothermal power.

Table 11: CDM/GEF effectiveness in reducing CO_2 via geothermal power

	Logit selection model, clustered SE		Random effects model, robust SE			Blundell-Bond GMM system model, one step, robust SE			Blundell-Bond GMM system model one step, robust SE		
	dy/dx	SE	Coeff.	SE		Coeff.	SE		Coeff.	SE	
Lagged DV			0.862	(0.045)	***	0.813	(0.041)	***	0.884	(0.024)	***
CDM	0.000	(0.000)	0.004	(0.002)	*	0.004	(0.003)		0.006	(0.003)	**
GEF	0.005	(0.003) *	0.005	(0.002)	**	0.007	(0.002)	***	0.010	(0.002)	***
Knowledge	-1.464	(1.988)	-136.51	(126.64)		-122.135	(93.685)				
Policies	0.061	(0.045)	-0.222	(0.301)		-0.244	(0.199)				
Oil imports	0.010	(0.005) **	0.390	(0.371)		0.422	(0.346)				
GDP per capita	0.002	(0.002)	0.027	(0.122)		-0.053	(0.122)				
Nat. resources	-1.864	(16.342)	9.509	(3.848)	**	12.606	(4.271)	***			
ODA	0.015	(0.015)	0.497	(0.167)	***	0.528	(0.130)	***			
Constant			1.257	(1.265)		2.146	(1.332)		0.651	(0.482)	
Year FE	Yes		Yes			Yes			Yes		
N	2010		164			164			164		
Groups	122		10			10			10		
F-/Wald-test	0.00	(Wald, p-value)	-	(Wald, p-value)		0.00	(Wald, p-value)		0.00	(Wald, p-v.)	
Various stat.	0.16	(Pseudo- R^2)	0.97	(R^2)		0.51	(AR2, p-value)		0.83	(AR2, p-v.)	
Hansen test						1.00	(p-value)		1.00	(p-value)	
# instruments						229			158		
Endogenous variables	-		-			CDM, GEF, ODA, policies			-		

Dependent variable: tonnes of CO_2 reduced with geothermal power generation, per million USD of GDP 2007 USD), assuming 500 tCO_2 reduced per GWh of renewable power production

Significance levels: * = p-value of coefficient <0.1, ** = p-value <0.05, *** = p-value <0.01

Consistent with theory, the Blundell Bond coefficient for the lagged dependent variable is between 0.766 (fixed effects coefficient) and 0.862 (coefficient of OLS model with control variables, see annex)

5.6.3 Hydro power

CDM has no significant impact on diffusion of hydro power production (see Table 12), although the coefficient in the BB model is close to significance, and actually becomes significant at the 90% level in few alternative specifications (see Annex 10.2.5). GEF finance perfectly predicts the use of hydro power in a country but has no significant impact on diffusion, which does not depend on the model specification.

Among control variables, policies perfectly predict the existence of hydro power. Natural hydro resources and oil imports support the adoption of hydro power but have no significant influence on diffusion. In the Logit selection model, ODA for RE negatively influences the adoption of grid-based hydro power. This may be due to the focus of hydro-related ODA on rather poor countries with a low electrification rate – e.g. among the small part of ODA for RE that is channeled through multilateral organizations, most is flowing through the IDA (see Figure 13), the World Bank Group's funding institution for less-affluent countries.

In general, it is very difficult to model hydro power due to large fluctuations from year-to-year that may be related to local changes in water availability at the hydro power locations. Our national hydro resource variable neither captures such local variability nor water flowing cross borders.

Table 12: CDM/GEF effectiveness in reducing CO_2 via hydro power

	Logit selection model, clustered SE			Random effects model, robust SE			Blundell-Bond GMM system model, one step, robust SE			Blundell-Bond GMM system model, one step, robust SE	
	dy/dx	SE		Coeff.	SE		Coeff.	SE		Coeff.	SE
Lagged DV				0.954	(0.014)	***	0.964	(0.019)	***	0.951	(0.023)
CDM	-0.000	(0.000)		0.009	(0.011)		0.018	(0.014)		0.022	(0.015)
GEF	Predicts success perf.			-0.008	(0.009)		-0.009	(0.025)		-0.005	(0.014)
Knowledge	0.736	(0.704)		-13.905	(9.970)		-17.550	(12.476)			
Policies	Predicts success perf.			11.876	(5.589)		24.603	(18.691)			
Oil imports	0.001	(0.000)	*	0.055	(0.059)		0.122	(0.153)			
GDP per capita	-0.004	(0.003)		-0.027	(0.224)		-0.092	(0.260)			
Nat. resources	0.118	(0.026)	***	2.146	(2.008)		2.766	(2.745)			
ODA	-0.002	(0.001)	**	-0.078	(0.131)		-0.587	(0.576)			
Constant				-1.581	(3.612)		-2.959	(3.836)		2.470	(7.602)
Year FE	Yes			Yes			Yes			Yes	
N	1800			1625			1625			1625	
Groups	121			101			101			1101	
F-/Wald-test	0.00	(Wald, p-value)		0.00	(Wald, p-value)		0.00	(Wald, p-value)		0.00	(Wald, p-v.)
Various stat.	0.22	(Pseudo- R^2)		0.99	(R^2)		0.20	(AR2, p-value)		0.10	(AR2, p-v.)
Hansen test							0.00	(p-value)		1.00	(p-value)
# instruments							505			219	
Endogenous variables	-			-			CDM, GEF, ODA, policies			-	

Dependent variable: tonnes of CO_2 reduced with hydro power generation, per million USD of GDP (2007 USD), assuming 500 tCO_2 reduced per GWh of renewable power production

Significance levels: * = p-value of coefficient <0.1, ** = p-value <0.05, *** = p-value <0.01

The Blundell Bond coefficient for the lagged dependent variable is not between 0.914 (fixed effects coefficient) and 0.961 (coefficient of OLS model with control variables, see annex 102.5), as would be required for a credible estimator. For a credible coefficient, see the Blundell Bond estimations without endogenous variables that produce similar results (see annex 10.2.5).

5.6.4 *Solar power*

In the solar power models (see Table 13) the CDM is not included as no carbon credits for solar power have been issued until the end of 2009. GEF has no significant influence on solar power diffusion. In only one alternative model specification – if we model solar power generation per capita (instead of per GDP) – the GEF impact is significant, although substantially lower than officially claimed (see Annex 10.2.6).

Among control variables, oil imports, GDP and development assistance directed at solar power increases the chance of adopting solar power but only development assistance has a significant impact on diffusion (FE model). Solar irradiation and oil imports have a significant positive influence on diffusion in some alternative specifications (see Annex 10.2.6)

Table 13: CDM/GEF effectiveness in reducing CO_2 via solar power

	Logit selection model, clustered SE		Fixed effects model, robust SE		Blundell-Bond GMM system model, one step, robust SE		Blundell-Bond GMM system model, one step, robust SE	
	dy/dx	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Lagged DV			0.485	(0.024) ***	0.849	(0.042) ***	0.913	(0.017) ***
CDM								
GEF	0.000	(0.000)	-0.000	(0.000)	-0.000	(0.000)	-0.000	(0.000)
Knowledge	-0.059	(0.050)	0.044	(0.155)	-0.190	(0.276)		
Policies	-0.009	(0.013)	0.009	(0.006)	0.004	(0.007)		
Oil imports	0.006	(0.002) ***	0.028	(0.030)	0.044	(0.028)		
GDP per capita	0.003	(0.002) *	0.001	(0.003)	-0.001	(0.001)		
Nat. resources	-0.013	(0.013)			0.041	(0.028)		
ODA	0.037	(0.018) **	0.004	(0.001) ***	-0.012	(0.011)		
Constant			0.026	(0.026)	-0.194	(0.142)	0.009	(0.004)
Year FE	Yes		Yes		Yes		Yes	
N	2009		125		125		125	
Groups	122		13		13		13	
F-/Wald-test	0.00	(Wald, p-value)	-	(Wald, p-value)	0.00	(Wald, p-value)	0.00	(Wald, p-v.)
Various stat.	0.11	(Pseudo- R^2)	0.85	(R^2)	0.27	(AR2, p-value)	0.25	(AR2, p-v.)
Hansen test					1.00	(p-value)	1.00	(p-value)
# instruments					173		130	
Endogenous variables	-		-		CDM, GEF, ODA, policies		-	

Dependent variable: tonnes of CO_2 reduced with solar power generation, per million USD of GDP (2007 USD), assuming 500 tCO_2 reduced per GWh of renewable power production

Significance levels: * = p-value of coefficient <0.1, ** = p-value <0.05, *** = p-value <0.01

Consistent with theory, the Blundell Bond coefficient for the lagged dependent variable is between 0.485 (downward biased fixed effects coefficient) and 0.984 (upward biased coefficient of OLS model with control variables, see annex 10.2.6).

5.6.5 Wind power

In case of wind power (see Table 14), CDM perfectly predicts the adoption of wind power but has no significant impact on the diffusion. In contrast, GEF has no influence on adoption of wind power but on diffusion. However, the model without control clearly overestimates the effectiveness. GEF's effect is most pronounced in short- and mid-term (1 to 6 years after funding approval), while no long-term effect can be found, see annex 10.2.7. GEF's impact also remains stable in most alternative specifications, e.g. when modeling wind energy generation per capita instead of per GDP, or as percentage of overall power production. However, the impact vanishes if real grid factors are used.

Oil imports, GDP and ODA all promote the adoption but not the diffusion of wind power. Wind power policies are significant in the BB model, if the alternative specification for policies – total number instead new ones added in the three previous years – is used. Furthermore, liquid liabilities and the oil price have a significant influence (see alternative specifications in Annex 10.2.7).

Table 14: CDM/GEF effectiveness in reducing CO_2 via wind power

	Logit selection model, clustered SE			Fixed effects model, robust SE			Blundell-Bond GMM system model, one step, robust SE			Blundell-Bond GMM system model, one step, robust SE		
	dy/dx	SE		Coeff.	SE		Coeff.	SE		Coeff.	SE	
Lagged DV				0.932	(0.132)	***	0.972	(0.080)	***	0.927	(0.126)	
CDM	Predicts success perf.			0.001	(0.002)		0.001	(0.002)		0.001	(0.002)	
GEF	-0.000	(0.000)		0.002	(0.001)	***	0.002	(0.000)	***	0.003	(0.001)	**
Knowledge	0.261	(0.226)		-0.242	(0.497)		-0.251	(0.737)				
Policies	0.039	(0.026)		0.036	(0.040)		0.044	(0.028)				
Oil imports	0.109	(0.004)	***	0.224	(0.171)		0.023	(0.028)				
GDP per capita	0.004	(0.004)	**	-0.010	(0.027)		-0.004	(0.007)				
Nat. resources	0.006	(0.017)					-0.003	(0.027)				
ODA	0.109	(0.057)	*	-0.078	(0.084)		-0.005	(0.071)				
Constant				-0.120	(0.058)	*	0.526	(0.268)		0.526	(0.268)	
Year FE	Yes			Yes			Yes			Yes		
N	1973			240			240			240		
Groups	122			25			25			25		
F-/Wald-test	0.00	(Wald, p-value)		-	(Wald, p-value)		0.00	(Wald, p-value)		0.00	(Wald, p-v.)	
Various stat.	0.16.	(Pseudo- R^2)		0.92	(R2)		0.28	(AR2, p-value)		0.28	(AR2, p-v.)	
Hansen test							1.0	(p-value)		1.0	(p-value)	
# instruments							292			185		
Endogenous variables	-			-			CDM, GEF, ODA, policies			-		

Dependent variable: tonnes of CO_2 reduced with wind power generation, per million USD of GDP (2007 USD), assuming 500 tCO_2 reduced per GWh of renewable power production
Significance levels: * = p-value of coefficient <0.1, ** = p-value <0.05, *** = p-value <0.01
Consistent with theory, the Blundell Bond coefficient for the lagged dependent variable is between 0.932 (downward biased fixed effects coefficient) and 1.021 (upward biased coefficient of OLS model with control variables, see annex 10.2.7).

5.6.6 *Comparing results with hypotheses*

Our first hypothesis has been that the CDM has a positive, immediate effect on RE diffusion in the short-term, while the GEF rather has a lagged effect. We have to partly reject this hypothesis as we have only found a significant influence of CDM on biomass and potentially on geothermal and hydro power, and only a significant influence of GEF on wind and potentially geothermal power. Furthermore, GEF's influence on geothermal and wind power has not only been lagged (up to 6 years) but also immediate in the first two years after approval (see annexes 10.2.3 and 10.2.7). This suggests that GEF's financing of pilot plants with its rather immediate benefits has been equally important as capacity building and policy support with its longer term focus.

The second hypothesis has been that CDM and GEF effectiveness in promoting RE is lower than officially reported. For evaluating this hypothesis, we compare the official estimates for effectiveness per USD of funding with the effectiveness estimated in the full models controlling for all variables. For making numbers comparable, we have to multiply the estimated coefficients, which represent the one-year change in renewable energy production per USD of funding, with a credible lifetime of new RE plants. According to CDM and GEF documents, RE plants have 20 years lifetime on average (see Table 8), Under this 20 year lifetime assumption, the overestimation hypothesis is only rejected in case of CDM's support for biomass power. In all other cases, effectiveness has been either much lower than officially claimed (see Figure 16), or we have not found any significant effects at all. However, due to the large standard errors, the model estimate effectiveness is not significantly below the reported effectiveness in case of geothermal and hydro power. The results also show that BB models without any control variables tend to overestimate the effectiveness.

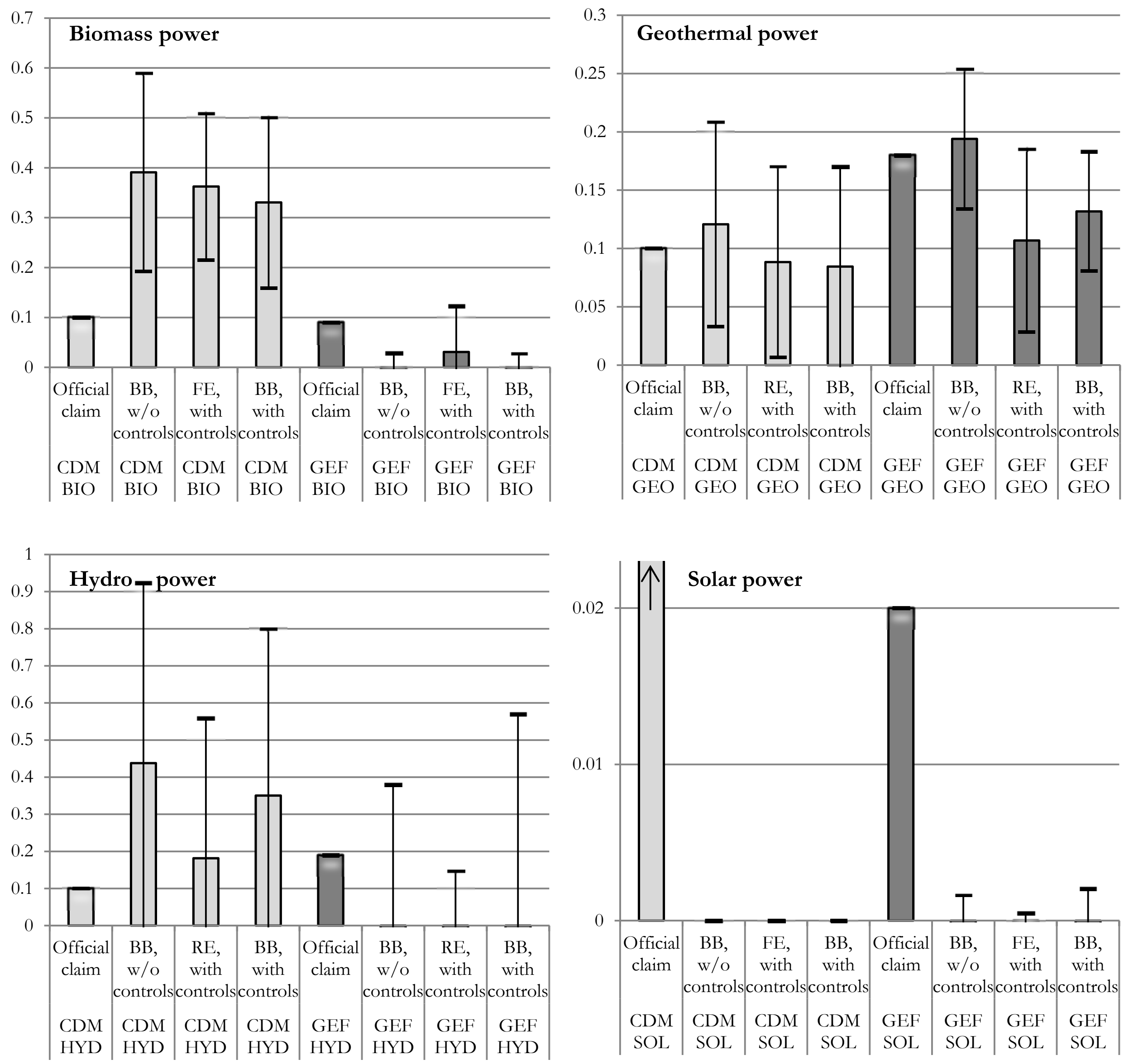
In fact, real effectiveness may be even lower and overestimation by official figures higher, as the 20 year lifetime may be too optimistic: lifetimes may be lower both because of technological failure and because promising RE sites would also be harvested without CDM and GEF after some years. This idea is also supported by the estimated coefficients on the lagged dependent variable. According to these coefficients (between 0.65-0.95), lifetimes of new RE power plants are substantially below 20 years for all RE plants except hydro[62]. If we use lifetimes according to these coefficients, even the effectiveness of CDM support for biomass plants is overestimated by official estimates (see Annex 10.2.8), and the overestimations are always significant with the exception of support for hydro power.

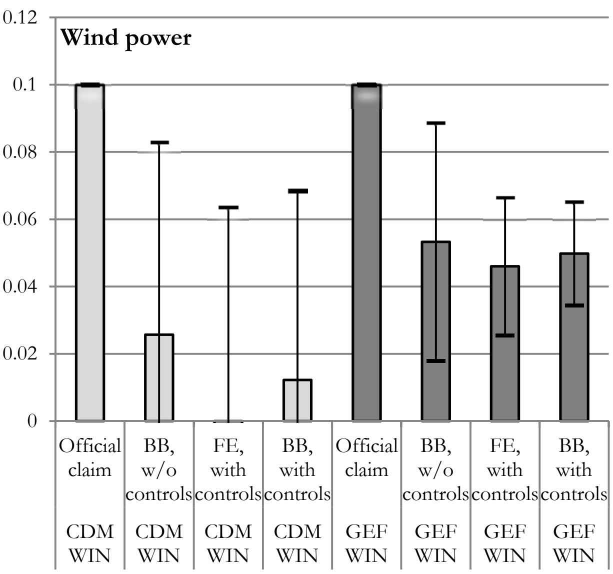
Our third hypothesis has been that the CDM is more effective per USD of funding than the GEF in promoting biomass, solar and wind power, while the GEF is more effective in case of geothermal and hydro. We have to reject any hypotheses on differences except for the case of biomass, where CDM has been clearly more effective. In all other cases, the differences between effectiveness are not significant, when looking at the 90%-confidence intervals in Table 16 (whiskers), although we estimated a higher mean effectiveness for CDM in case of hydro, and a higher one for GEF in case of geothermal and wind.

The assumed carbon price (10 USD per tCO_2) does not affect the testing of hypothesis 1, as significance of CDM coefficients will not change, and also not the testing of hypothesis 2, as the same carbon price is both assumed in case of official and estimated CDM effectiveness, so judgments on "over-estimation" should not be affected. However, in case of hypothesis 3 (GEF-CDM comparison), the carbon price matters, as it affects the CDM but not the GEF coefficient. However, our conclusion that only in case of biomass power there is a significant difference is not very sensitive to the carbon price assumption: lower assumed carbon prices do not affect this finding at all, while higher carbon prices can have an effect but the assumed price has to be at least double (20 instead of 10 USD per tCO_2), in order that there are some changes: GEF becomes significantly more effective than CDM in case of wind and geothermal power (BB models). In case of biomass, even a carbon price of 50 USD per tCO_2, higher than the all-time high of the CDM secondary price, would not affect the significant difference between CDM and GEF.

[62] The lifetimes of RE plants (biomass = 2.7 years, geothermal = 8.6, hydro = 21.7, solar = 11.5 and wind =13.7) were estimated by the following formula: $\sum_{i=0}^{100} \gamma^i$ (with γ = coefficient of the lagged dependent variable, in the full Blundell Bond models).

Figure 16: Effectiveness of CDM / GEF in tCO_2 reduced per USD of funding (20 years persistence of effect assumed)





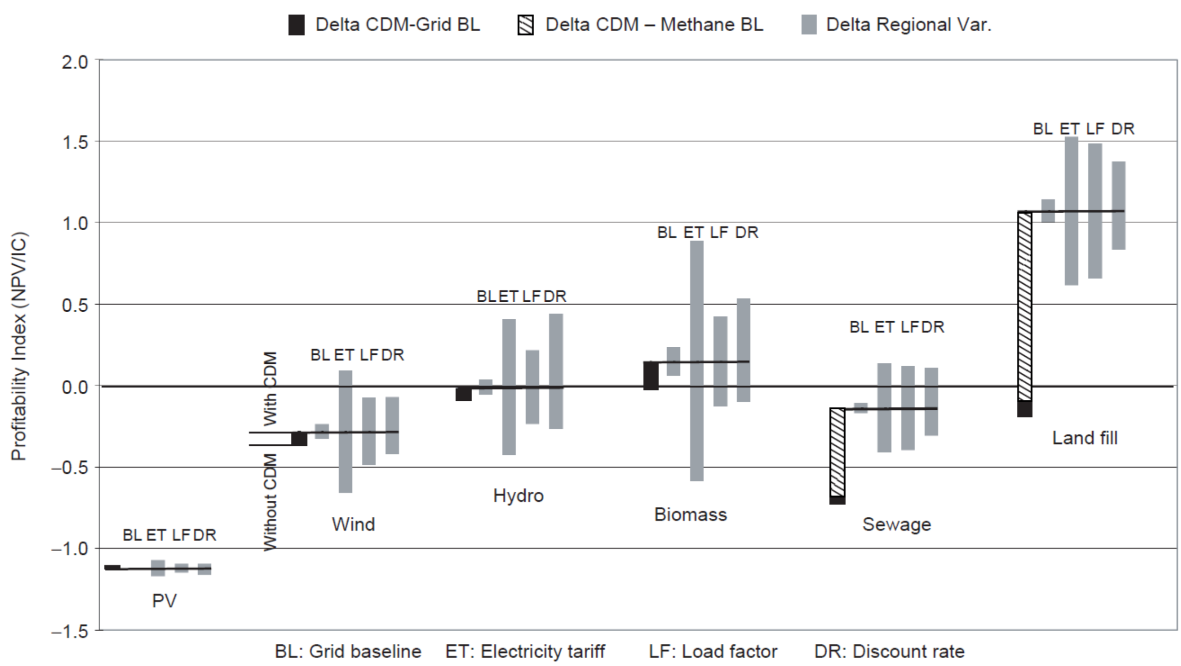
Notes:
In case of OLS, fixed effects (FE), random effects (RE) and Blundell Bond estimates, the bars show the mean values, while the whiskers indicate the 90% confidence interval. In case where the lower whisker of the 90%-confidence interval is outside the graph, no significant effect has been found. Values are based on 20 year technology lifetimes and 500 tonnes of CO_2 reduced per GWh of renewable electricity production.
To make comparison with coefficients possible, CDM official claims show reported effectiveness per USD of funding (0.1 tCO_2 per USD, using the same carbon price as in the models - 10 USD per tCO_2).

5.7 Discussion

5.7.1 Explanations for differences between technologies

The insignificant effect of CDM in case of wind, solar and probably geothermal and hydro power can be explained with the arguments discussed in the theoretical section: information on the real drivers for RE adoption is missing and different actors have incentives not to reveal information, which makes it impossible for evaluators and voters to assess whether CDM funding is vital for the decision to invest in RE projects. According to our result, the overestimation may even be larger than expected, as CDM has not clearly a significant impact on any technology except biomass. Actually, these findings correspond well to the results of case studies (e.g. Michaelowa and Purohit, 2007; Schneider, 2007; Haya, 2009). Our results that CDM has a significant effect only on biomass (and may be hydro) power is also consistent with the findings of Schneider (2007) and Schneider et al. (2010) that among different renewable energies, CDM impact is only substantial in case of biogas power that also receive CDM credits for methane reductions (e.g. landfill gas power, which is in our case also part of biomass power). While CDM can make solid biomass and hydro power projects under specific circumstances (e.g. electricity price, discount rates) profitable, this is hardly ever the case for wind power and solar photovoltaic (PV) power, see Figure 17. The modeling results, therefore, support from a macro perspective what has been found at a micro level.

Figure 17: Impact of CDM funding on profitability of different RE technologies



Source: Schneider et al. (2010); note: profitability above zero implies that projects are profitable

The overestimation of GEF funding corresponds well to our hypothesis, which was based on the deficient CO_2 calculation methodologies (Mee et al., 2008; Stadelmann, 2009) and the incentive for host countries and implementing agencies to claim high benefits of their projects in order to make the approval process easier. In contrast, the non-significant effect in case of biomass, hydro and solar power is more difficult to explain. One general reason may be that the fixed allocation of funding to countries (GEF, 2010c) clearly reduces the incentive to develop sound projects. Furthermore, we may find reasons that are very specific for each technology. In case of solar power, the likely reason for no significant impact is linked to very high mitigation costs of solar power (Schneider et al., 2010; Edenhofer et al., 2011), which cannot be lowered by GEF's capacity building or framework policy support. In case of hydro power, the information and regulatory barriers the GEF often targets may be relatively unimportant, as hydro has been an already established technology in many countries before the GEF was founded: more than three quarter of the countries in our sample already had hydropower at this time (EIA, 2010). Finally, in case of biomass power, GEF's non-significant influence is rather surprising.

The finding that, in case of solar and wind power, CDM is probably not more effective than GEF, may be linked to the potential non-ability of the CDM to mobilize any solar or wind power projects at all. In case of biomass including landfill gas, where the CDM is likely to have a major impact (see Figure 17), CDM indeed outperforms the GEF as predicted, probably related to the well-established carbon assessment methodologies as discussed in the theory section, or to the direct incentives provided. However, in case where CDM's support cannot or is unlikely to overcome the profitability threshold (e.g. solar and wind, see Figure 17), CDM credits may in many cases just be an additional income for RE investors but not the one that determines the investment decision, although CDM developers may claim in official documents that CDM is decisive. This idea is not only consistent with the case study literature Michaelowa and Purohit, 2007; Schneider, 2007; Haya, 2009; Schneider et al., 2010; World Bank, 2010) but also with the following confidential statements made by insiders in the last 5 five years, when the author challenged additionality of their CDM projects:

"Yes, the CDM is just the icing on the cake" (International wind power lobbyist)

"Investments in RE are not happening because of the CDM" (RE investor in East Asia)

"As far as I understand, you just adapt the numbers so that projects seem to be additional" (European developer of hydro power plants in China)

"I can create you any document you need for showing additionality" (Chinese RE developer)

In case of RE technologies where CDM funding is not decisive (generally all RE except biomass projects with methane component), public finance programs may have some advantages compared to the CDM, as they can target investment barriers beyond technology cost, such as missing information or regulatory barriers.

5.7.2 Validity of estimated effectiveness per USD

This section discusses to which extend our estimated effectiveness of GEF and CDM are valid. Three issues are considered: the assumed CO_2 emission reductions per unit of renewable electricity production, the validity of the models used and the validity beyond the macro level.

First, our estimated GHG emissions reductions per dollar of GEF and CDM funding rely on the assumption that CO_2 emissions are reduced by feed-in of renewable power into the grid. We calculated the reductions due to RE feed-in to the grid by multiplying RE power generation with the IEA (2009b) grid emission factors. With this calculation, we assume two things: on the one hand, we assume that each unit of RE produced will replace one average unit of electricity in the grid. However, this is not necessarily true, given that additional production should lead to lower electricity prices and increased electricity consumption, as the electricity demand is not fully inelastic to electricity prices (Lijesen, 2007). Furthermore, the electricity market in many developing countries is not fully liberalized (e.g. Spalding-Fecher and Matibe, 2003), so we cannot be sure that regulators will plan less fossil fuel electricity production due to additional renewable power plants. On the other hand, by using the IEA (2009b) factors, we assume that new electricity displaces the "average" power production, which consists of around 75% of fossil fuel power generation in developing countries (EIA 2010). However, it may be the case that some types of power plants may reduce their production more than others[63]. Empirically, York (2012) has estimated, using a cross-country regression model, that each additional unit of renewable electricity production only reduces around 10% of the same unit in fossil fuel electricity production, so lower than the 75% we assumed by using the average IEA (2010) grid factor. If York's estimation is correct, then our estimates for effectiveness of CDM and GEF are too optimistic. However, further studies on fossil fuel replacement rates may be needed.

One of our additional assumptions in the GHG estimation is that RE power plants do not lead to GHG emissions by themselves. However, at least for Brazil, there are two potential types of substantial GHG emissions: first, hydro power plants may enable soy bean production, which may lead to deforestation (Cole and Roberts, 2011), and second, large hydropower reservoirs in tropical regions may imply substantial methane emissions (Rosa et al., 2004; dos Santos et al., 2006). Similar to the case of the RE-fossil replacement rate, more studies on these emission sources would be needed.

Secondly, the validity of the estimated effectiveness also depends on the macro level models we used to compare diffusion of renewable energies in different countries. Such macro level models have their own pitfalls such as the need to reduce the real-world complexity and the risk of omitting important variables. However, we tested the robustness of our results by applying different models and including different variables, and the main findings (overestimations, significance) remain similar (see Annex 10.2.3-7). Another challenge for the model validity may be that the effects on the macro level may not be significant because of two reasons: the first reason is that CDM and GEF may only fund a very small portion of RE projects in many countries and, therefore, their effect may not become visible, even if individual projects are effective. However, this problem should hardly affect the modeling results for wind, hydro and biomass power, where CDM supports one sixth or more of newly installed capacity in a median country (Spalding-Fecher et al., 2012: 91ff). The second reason is that the lagged dependent variables explain a very large part of the variation, which may render CDM and GEF coefficients insignificant. However, the main findings do not change if we estimate BB models using the differences as dependent variable[64]. Summing up, several issues could challenge the validity of the models but our sensitivity analyses do not question the results.

Thirdly, is our estimated effectiveness in promoting RE technologies valid beyond the macro level? As we only estimate the average over all countries, the two funding channels may have different

[63] In case of the CDM, it is assumed that primarily flexible production such as natural gas and coal power is reduced, while hydro and other renewable power stations are considered as power plants that have low marginal generation costs and will, therefore, continue to run even when additional power is fed into the grid. Because of this assumption, the average country grid factor in the CDM is 820 tCO_2 per GWh (IGES, 2012), i.e. higher than what we assumed in the regressions (500 tCO_2 per GWh). So we may both have underestimated the GHG emissions reductions by assuming an "average" replacement in the grid, or overestimated it by assuming one-to-one replacement.

[64] The significant GEF and CDM coefficients slightly decrease. Similar as in case of modeling % of electricity production, the CDM coefficient becomes significant for geothermal power, while the GEF one turns insignificant (see Annex 10.2.3-7). Also when estimating fixed or random-effects models with differences as dependent variables (not displayed in the Annex) results remain similar.

effectiveness in case of specific countries or projects. For instant, the substantially varying profitability of RE technologies in different developing countries (Schmidt et al., 2012) indicate that, given a specific carbon credit price, CDM may be able to overcome investment barriers in case of some countries will it may have no significant impact in others. This is also the case for some CDM biomass power projects that have been found to be BAU (Michaelowa and Purohit, 2007; Schneider, 2007), so the overall CDM effectiveness in promoting biomass does not mean that all CDM biomass projects are effective.

5.8 Conclusions

This study has found that CDM and GEF as international climate finance mechanisms have only a limited effect on the reduction of GHG emissions through renewable energies. CDM has only an effect on biomass and potentially geothermal and hydro power, while GEF influences wind and potentially geothermal power diffusion. The effects are in all cases lower than officially estimated (except CDM's impact on biomass power), which is what we expected from theory given the many drivers of RE and the substantial interest of various actors to overestimate effectiveness and not reveal information. Interestingly, the CDM is only in case of biomass more effective per USD of funding than the GEF, which is in contrast to some of our theoretical expectations. The main explanation for the low effectiveness of CDM is that only in case of biomass power with methane reductions the CDM support is substantial enough to make projects profitable. Other projects claim that CDM funding is needed but actually, other determinants such as oil dependence or national policies may drive the investment decision. Actually, the CDM EB may be aware that renewable energies are driven by national policies, but – in order to avoid perverse incentives – it has made clear that climate-friendly national policies adopted after 2001 do not impede the registration of CDM projects (UNFCCC, 2005b). Due to this rule, policy makers may have an incentive to set-up RE policies as they can expect that CDM will cover part of the policy costs. Therefore, the CDM may be more effective than estimated by our models, if we find a significant impact of CDM on RE policy adoption in the next chapter.

What do these results imply for the future of international climate finance? In case of CDM, the lower and in some case even non-significant effectiveness substantially questions whether the CDM fulfills its core functions according to the Kyoto Protocol, namely to assist industrialized countries in achieving their emission targets. If CDM credits for renewable energies do not lead to additional CO_2 reductions (or only to a very limited extent), then industrialized countries buying CDM credits from renewable energies may only seemingly fulfill their Kyoto targets. In fact, if CO_2 emissions are correctly accounted for, it may be cheaper for them to reduce CO_2 reductions domestically than by purchasing CDM credits from RE projects in developing countries. Therefore, it may be warranted for industrialized countries to lower the purchase of CDM credits from renewable energies until regulatory reforms to improve the effectiveness of the CDM in promoting renewable energies are undertaken. Such reforms would have to make sure that CDM credited renewable energies are either enabled by direct CDM financing or via CDM support for policies.

Among the many CDM reform options proposed (Schneider, 2009b; Bakker et al., 2011) there are at least three relevant options for improving the CDM's effectiveness in promoting renewable energies. First, the existing assessment tools whether CDM projects are additional to BAU case could be tightened, see Schneider (2009). However, a tightening will certainly also imply that more projects needing support will be excluded. Instead of false positives, so projects approved even when they do not need CDM support, we will find more false negatives (Trexler et al., 2006), so projects are not approved even if they need CDM support. A second CDM reform option is to create positive list (UNFCCC, 2009a) for technologies not needing an additionality test and negative lists (Wara, 2007) for non-eligible

RE technologies. While such lists can create investment certainty and weed out specific project types where CDM effectiveness is unlikely, these lists may create false positives and false negatives on their own. Furthermore, these lists will have to be adapted over time due to changing economics of technologies. A third option is to combine CDM or other carbon credits with other support from industrialized countries (Castro et al., 2011b): as long as the carbon price is not high enough for making renewable energies profitable, a mix of carbon credits, public finance and national policies may be applied to close the cost gap. In such cases, it will have to be guaranteed that only the CDM credit buyer but not the public finance provider or the national government claims the CO_2 emission reductions (Hayashi and Wehner, 2012).

In case of GEF our results suggests that GEF funding has an impact on diffusion of wind and potentially geothermal power but the effect is lower than claimed, while GEF has no effect on other renewable energies. These findings are particularly useful as GEF projects have only been evaluated at a project level, while this study has looked at the country level. The overestimated effect certainly implies that methodologies for calculation of CO_2 estimations have to be more elaborated; it also means that GEF's tools like capacity building and regulatory reforms are not likely to be successful in case of technologies that are already well established (hydro power) or very far from being economically attractive (solar power), while they may be more appropriate in cases where technologies are already or almost commercially attractive but information and regulatory barriers exist (biomass, geothermal and wind power). A focus on promising technologies may therefore be warranted.

Our results have also shown that RE policies are substantial drivers for RE diffusion, which is consistent with many case studies. Therefore, international climate finance may have to focus more on approaches that promote the adoption of RE policies. One such approach is not only to credit projects as in case of the CDM but also national policy actions. Related ideas are the crediting of Nationally Appropriate Mitigation Actions (Okubo et al., 2011) and sectoral crediting (Schmidt et al., 2008; Ward et al., 2008). Another approach is to more closely link public financing to the implementation of national policies. While, at the moment, all developing countries receive GEF funding, future funding could focus on countries with ambitious mitigation policies. As making funding strictly conditional upon national policy reforms has not been particularly successful in case of development assistance (Collier et al., 1997; Killick, 1997), other ways of promoting national RE policies via climate finance may have to be found, such as rewards for long-term positive changes (Collier et al., 1997). Another approach that avoids conditionality is information transmission (Killick, 1997) but this would resemble GEF's capacity building approach that apparently seems to be less effective than officially claimed.

As input for this discussion on how international climate finance can promote renewable energy policies, it may be interesting to study past effectiveness in inducing policies, which is conducted in the next chapter.

6 Climate policy innovation in the South - domestic and international drivers for renewable energy policies in developing and emerging countries[65]

Abstract

This article aims to disentangle the drivers of the adoption of renewable energy (RE) support policies in developing and emerging countries. By analyzing policies already implemented in industrialized countries, we focus on diffusion but not invention of climate-relevant policies. We look at four different types of policies (RE targets, feed-in tariffs, other financial incentives and framework policies) and consider both domestic factors and international diffusion mechanisms utilizing a discrete-time events history model with a Logit link on a self-compiled dataset of RE (grid-based electricity) policy adoption in 114 developing and emerging countries from 1998 to 2009. In general, we find stronger support for the domestic drivers of policy adoption, but also substantial influence from the international level. Countries with a larger population and a higher income will have a higher probability of adopting RE policies. Having natural endowments for producing RE does only in specific cases encourage governments to adopt policies, and hydro power resources may even deter the adoption of targets. Among the international drivers, learning from countries with the same former colonizer and membership within the EU seem to facilitate policy adoption. International climate finance flows are less relevant, as capacity building via the Global Environmental Facility and incentives under the Clean Development Mechanism only tend to increase the adoption of framework policies and targets, while they have no influence on financial incentives and feed-in tariffs in the short- and medium term.

Keywords: Renewable energies, policy diffusion, developing countries, climate finance

[65] This chapter has been written together with Paula Castro.

6.1 Introduction

Energy generation and use is one of the most important global sources of GHG emissions. Electricity and heat production accounted for 28% of global emissions in 2005 (WRI, 2012). Renewable energy (RE) is increasingly considered by policy-makers as a key energy form to support and pursue, not only to prevent climate change, but also to improve energy security, reduce local air pollution and generate employment (Mitchell et al., 2011). For this reason, in this chapter we will focus on the adoption of policies that support RE electricity generation.

There is a growing body of literature that focuses on the national adoption of policies that financially support or otherwise promote the deployment of RE, such as feed-in tariffs (FITs), renewable portfolio standards or tax credits. Most of the empirical literature, however, looks at industrialized countries or at sub-national units in industrialized countries (Jacobsson and Lauber, 2006; Vachon and Menz, 2006; Huang et al., 2007; Matisoff, 2008). Also the most recent work on adoption of climate and energy policies using quantitative diffusion models focuses on the EU (Schmitt et al., 2012) or US states (Matisoff and Edwards, 2012).

Empirical work on RE policies in developing countries mostly focuses on the policies' impact (Lewis and Wiser, 2007; Yu et al., 2009; Wang et al., 2010), whereas literature on policy adoption is limited to few case studies (e.g. Benecke, 2009). However, knowing the drivers that encourage developing and emerging country governments to adopt RE policies is very important from an international climate policy perspective; developing countries already generate more than half of global GHG emissions, will substantively expand their power generation facilities in the next few decades and are, therefore, projected to contribute more than 70% of energy-related GHG emissions by 2035 (IEA, 2010a). Whether policy adoption drivers are the same as in industrialized countries is questionable, given the difference in political systems, international commitments to mitigate climate change[66], and economic development. For instance, the rapid growth in emerging economies at a time of high oil prices may have encouraged the search for alternative energy forms. Furthermore, less affluent countries may need international financial and capacity building support to implement RE technologies with high investment costs. Therefore, we can expect that international climate finance, both from public sources and the carbon market will help to set up new policies.

According to our knowledge, these potential differences between developing and developed country policy adoption have not yet been analyzed. This article starts filling this research gap by analyzing the reasons why developing and emerging countries adopt RE support policies. Policies are understood here as national-level public policies[67], i.e. government decisions (Dye, 1972) on goals or means (Jenkins, 1978). Among the three aspects of climate policy innovation – invention, diffusion and impact of climate policies (Huitema and Jordan, 2012), we focus on the diffusion of policies already in place in other countries, as most of the RE policies observed in developing countries (e.g. FITs) have been invented in the North (REN21, 2007). Thereby, we follow Walker's concept of *policy innovation* as *first-time adoption of a policy in a country* (Walker, 1969: 881). Walker's policy innovation concept of one-time legislative adoption is a simplication, as policies are composed of a set of interrelated decisions (Jenkins, 1978). In reality, only the core concepts of policies may be diffused, e.g. the guaranteed electricity tariff in case of FITs, see Jacobs (2012), while their details, e.g. the actual level of the FIT, are elaborated in a domestic decision

[66] While developing countries have committed to undertake mitigation actions (see e.g. UNFCCC, 2010), the concrete measures are voluntary in nature and not legally binding such as industrialized countries' emission target under the Kyoto Protocol.
[67] In several developing countries, also sub-national policies are relevant for renewable energy, see e.g. the case of India (Schmid, 2012).

process. Therefore, our study can only capture the diffusion process of policies' core features, while the actual adaptation of policies to the country context would have to be studied by case studies.

Our focus on diffusion rather than invention allows us to analyze RE policies that have already proven to enable substantial reduction of carbon emissions in the North – e.g. FITs (see Mendonça, 2007; Butler and Neuhoff, 2008). Further advantages are that diffusion processes cover a larger part of developing nations and GHG emissions than invention processes, and that we can measure the impact of international climate finance, which will promote rather diffusion of Northern policies and not Southern inventions. As downside, our analysis neglects that developing countries can also be relevant inventors of RE policies, see e.g. the Brazilian Alcohol Program promoting the use of sugarcane as transport fuel in the 1970s (Moreira and Goldemberg, 1999).

Following Berry and Berry (2007), we assess whether it is mostly domestic factors that drive adoption – dependence on increasingly expensive fossil fuels, concerns about air pollution, domestic environmental pressure groups, socio-economic, structural and institutional factors (see e.g. Buen and Castro, 2012) –, or whether international policy diffusion mechanisms also play a role. We consider that both mechanisms of horizontal diffusion (between countries) and vertical diffusion (from the international to the national level) could be at play. These international diffusion channels may be linked to the diffusion mechanisms outlined in the literature: emulation, learning, coercion (including financial incentives) and competition (Simmons et al., 2006; Dobbin et al., 2007; Shipan and Volden, 2008). Policies could be emulated from neighboring countries or countries within the same region, with similar cultural and historical background. Diffusion among economic peers, particularly countries within the same trade bloc, may also be a signal of competition. Furthermore, diffusion may also be enabled by learning and financial incentives connected to international public finance and the carbon market.

These potential effects are tested using a panel dataset of RE support policies in 163 developing countries over the period from 1998 to 2009; the dataset was constructed using data from various international organizations (e.g. EBRD, 2011; IEA, 2011a; REEEP, 2011; REN21, 2011b). We use a discrete time event history model with a Logit link for estimating the probability of policy adoption of four selected policy types (RE targets, FITs, other financial incentives and policy frameworks), including time fixed effects to model the baseline hazard of adopting a policy.

We start the paper by giving an overview on RE policies in developing countries, their adoption patterns and potential drivers. Then we provide a theoretical framework for RE policy, adapted to developing and emerging countries, and derive hypotheses. After lining out the empirical strategy and the operationalization of the theoretical concepts, we present and discuss the empirical results, draw conclusions and propose directions for further research.

6.2 RE support policies in developing countries: A brief overview

The world is currently witnessing an accelerated development in the field of RE, in parallel with the rising needs for energy (IEA, 2010b). RE now accounts for about 13% of total global energy supply (Edenhofer et al., 2011), albeit most of this supply is still provided by traditional biomass used for cooking or heating in developing countries (roughly 6%) or by large-scale hydroelectric power (2.3%). Still, some modern RE sources – small-scale hydro, wind, solar, geothermal, tidal energy and biofuels – are growing very fast. For the past 5 years, solar photovoltaic and wind electricity capacity have grown at an average annual rate of 60% and 27%, respectively (REN21, 2010). About 19% of global electricity supply is now sourced from RE (Edenhofer et al., 2011). These trends are being witnessed both in industrialized OECD countries and in some emerging and developing economies.

In addition to economic drivers, such as rising energy demand and costs of fossil fuels (EIA, 2009), technological improvements and lowered technology costs due to learning and economies of scale (Junginger, 2005; Junginger et al., 2005; Nemet, 2006; Jamasb and Köhler, 2008), policies have been crucial for driving the growth in RE capacity (Mitchell et al., 2011). Governments have implemented technology-push policies, such as support for research and development (R&D), and demand-pull policies such as indicative and mandatory RE targets or financial incentives (REN21, 2010).

Internationally, renewable energies have been supported by development assistance and development banks since the 1980s, while further incentives emerged from the climate regime (e.g. GHG emission targets for industrialized countries and financial support for developing countries). In the following paragraphs, we describe the main domestic policy instruments related to RE deployment in developing countries, which are the focus of analysis of this article.

Different types of domestic policies can help to overcome the various barriers that prevent the diffusion of RE technologies. R&D and other technology-push policies are used for fostering innovations and long-term cost reductions in RE. Broader electricity-sector restructuring policies, including the liberalization of the sector, the regulation of access to transmission and distribution grids and the admittance of independent power producers may also affect RE deployment, depending on their design (Kozloff, 1998; Martinot et al., 2002).

The focus of this article is on policies directly promoting market growth of grid-based power generation by RE technologies. We classify such policies in accordance with the definitions used in IEA (2011b, 2011a) and REN21 (2011a)[68], as follows:

General strategy

- RE targets: goals for RE generation or installed capacity; usually strategy guidelines and not mandatory.
- Framework policies: generic plans and framework laws for the promotion of renewable energies.

Regulatory policies

- Renewable portfolio standards (RPS) or quotas: mandatory standards that establish a minimum portion of electricity generation or installed capacity to be from renewable sources. In this case, the government ensures that utilities meet the required targets.
- Feed-in tariffs (FITs) or production payments: instruments guaranteeing a price, over a certain period of time, at which power producers can sell electricity to the grid. Depending on policy design, the difference between the guaranteed price and the average electricity price can be covered by the consumer or by the government.
- Improved grid access: policies that grant a priority or a guaranteed access to the transmission and distribution network for RE sources.

[68] This structure is similar to the one used by Schaffrin et al. (2012), based on IEA (2011b, 2011a). Compared to the IEA classification, we exclude education and outreach, research and development, tradable permits as well as voluntary agreements here, as we have insufficient data on these policies. Furthermore, we add renewable energy portfolio standards, feed-in tariffs, grid access, competitive bidding and targets as these key policies are hidden in the IEA classifications.

Public financing

- Financial incentives: capital grants or concessional loans; investment or production tax credits; and reductions in sales, energy, value-added, import or other taxes.
- Public investments: Equity or debt financing originating from public sources, on a non-concessional basis (concessional loans are included under financial incentives above).
- Competitive bidding or tenders: a system of periodic tenders by which contracts to build and operate specific RE projects are awarded.

We have compiled a dataset of RE policies using data from different sources covering the years 1998 to 2009 (e.g. EBRD, 2011; IEA, 2011a; REEEP, 2011; REN21, 2011b). From the 163 analyzed developing and emerging countries, of which 21 are European economies in transition[69], 112 have some sort of policy or strategy to incentivize renewable power generation. The most common policies are targets, framework policies, the provision of financial incentives through tax reductions or subsidies, and FITs (see Table 15).

Table 15: Adoption of RE policies in developing and emerging countries (all policies)

Type of policy	Number of countries (excluding European economies in transition)		
	1999	2004	2009
General strategy			
RE targets	3(1)	18(11)	56(43)
Framework policies (strategies, plans, generic laws)	19(14)	55(41)	96(78)
Regulatory policies			
Renewable portfolio standards / utility quotas	0	3(1)	9(6)
Feed-in tariff and energy production payments	4(2)	15(9)	40(26)
Improved access to the electricity grid	4(2)	17(11)	26(16)
Other regulatory measures	3(2)	8(6)	13(10)
Public financing			
Financial incentives	7(4)	21(14)	42(30)
Public investment	2(2)	3(2)	17(13)
Competitive bidding / tenders	0	1(1)	8(6)
Research & development	5(4)	8(6)	13(10)
Total Countries with RE policies/strategies	31(22)	72(54)	112(92)

Numbers in parentheses exclude European economies in transition, which are sometimes not considered as developing or emerging countries

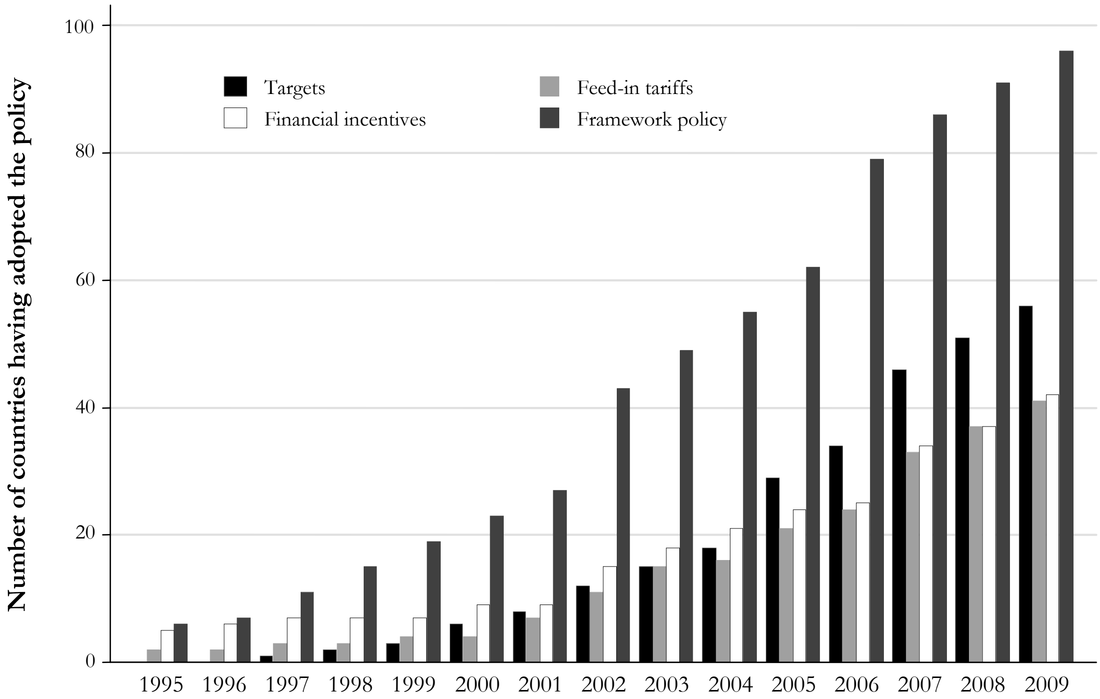
Source: Own compilation using data from IEA (2011b), REEEP (2011) and REN21 (2011b)

For the further analysis, we will focus on the four policy types that have diffused most, as depicted in Figure 18: RE targets, framework policies, FITs and financial incentives (grants, concessional loans and tax reductions). As Matisoff and Edwards (2012), we consider that different mechanisms may drive the adoption of different types of policies, thus the comparison across these four policies. Two of these policy types provide financial support (FITs and financial incentives), while the other two (targets and

[69] European economies in transition are defined as European countries who have undergone a transition from socialist to market economies after the downfall of the former Eastern bloc and Yugoslavia: Albania, Armenia, Azerbaijan, Belarus, Bosnia-Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Latvia, Lithuania, Macedonia, Moldova, Poland, Romania, Russia, Slovak Republic, Slovenia and Ukraine.

framework policies) are general strategies or guidelines, that often form the basis of more specific policies.

Figure 18: Adoption of RE policies in developing and emerging countries (4 analyzed policies)



Source: Own compilation using data from IEA (2011b), REEEP (2011) and REN21 (2011a)

Case studies have shown that domestic factors (e.g. the possibility of developing a new industry, generating employment and providing affordable energy access) are very important drivers of RE policies in developing countries (Mitchell et al., 2011: 879). However, the wide array of policies and the considerable variation in patterns of adoption shown in Table 15 and Figure 18 are an indication that not only domestic interests may drive policy adoption, but also external factors such as emulation and learning from peers, incentives provided by international climate policy initiatives or other policy diffusion mechanisms. Thus, in this study we aim at analyzing more systematically when, where and why new policies to support RE emerge in developing countries, and whether there are differences across different policies.

6.3 Policy adoption, innovation and diffusion: Theoretical background

As has been shown in Table 16, in recent years more and more developing countries have adopted one or various policies to support the development of RE. In agreement with the mainstream literature on policy innovation, we consider that a policy innovation takes place whenever a country adopts a new policy for the first time, even if such a policy already exists in other countries (Walker, 1969: 881). This allows us to consider both internal (domestic) drivers of policy adoption and external (international) diffusion mechanisms.

By both considering country-internal and external determinants, we follow the suggestion by Berry and Berry (2007) that a fully developed policy diffusion model cannot rely on internal or external covariates only; an approach also suggested by Tews (2005) for studying environmental policy diffusion. While we are aware that internal and external drivers may overlap (e.g. international public finance may only occur if domestic governments ask for support), we are separating them here conceptually.

Several theories seek to explain which factors affect the adoption of public policies. Environmental studies discuss environmental and resource pressures (Lester et al., 1983; Ringquist, 1994); developmentalists argue that socio-economic factors determine policy outputs and outcomes; institutionalist approaches posit that the political institutions and organizations in the country structure such policy decisions; public choice theory emphasizes the role of preferences and interests of different actors for decision-making and policy outcomes; sociological perspectives and policy diffusion theories underscore the role of formal and informal relationships and networks within and outside of the political system in determining policy outputs and outcomes (John, 1998). In the following, we draw from these theories for outlining our hypotheses regarding domestic and external drivers of policy adoption.

6.3.1 Domestic determinants

Environmental factors

Environmental and resource pressures are traditionally considered to be the trigger of policy-making in the environmental field: as populations grow, industrialization advances, and consumption increases, more pressures on the environment and the natural resources are generated. The severity of these problems is expected to influence environmental policy-making (Lester et al., 1983; Ringquist, 1994). A long tradition of studying environmental pressures exists, for example, in public policy studies that compare state-level policy making in the US (Ringquist, 1994; Sapat, 2004; Vachon and Menz, 2006; Huang et al., 2007). However, there are very few studies looking at environmental policy-making across developing countries (Fredriksson et al., 2005). In the energy field, increased energy demand and volatile or rising fossil fuel prices may make governments more willing to promote renewables due to energy security concerns, especially if they rely on fuel or electricity imports (Bird et al., 2005; Marques et al., 2010). Furthermore, local air pollution may motivate governments to support low-emission technologies such as RE. We hence expect that *energy-related environmental problems (domestic energy security and air pollution) may positively influence the adoption of policies that support RE deployment.*

Another environmental factor is the natural endowment with RE resources, such as solar irradiation, waterfalls or strong winds, which need to be present in sufficient quantity and quality to make RE investments competitive (Bird et al., 2005). We expect that *governments will more likely decide to support RE technologies if their countries have the natural resources to make them work in the first place.*

Socio-economic factors

Among the socio-economic factors, wealth and income have frequently been regarded as variables leading to stronger environmental policies, as policy adoption and implementation cost money (Lester and Lombard, 1990; Ringquist, 1994; Vachon and Menz, 2006). This should be especially true in a highly technical and investment-intensive field such as renewable power generation. Furthermore, higher levels of income are usually accompanied with stronger environmental preferences of the population (Elliott et al., 1997; Vachon and Menz, 2006)[70]. However, while empirical studies have sometimes found significant positive effects of wealth and income on environmental regulation (Ringquist, 1994; Zarnikau, 2003; Sapat, 2004; Fredriksson et al., 2005; Vachon and Menz, 2006), some have also found insignificant effects (Lester et al., 1983; Ringquist, 1994; Arkesteijn and Oerlemans, 2005), or even marginally significant negative effects (Ek, 2005). In our case, we expect a clear positive relationship especially in the case of policies that provide subsidies for RE, because they will require a government with sufficient resources to finance them, and because higher income may both lead to stronger environmental preferences and higher electricity demand. Thus, we expect that *higher levels of income will be associated with more adoption of policies that financially support RE deployment*.

Similarly, a higher level of education makes the population more aware of environmental issues (Elliott et al., 1997), and leads to a better assessment of the costs and benefits of different policy options. This results in increased support for environmental policies (Zarnikau, 2003; Vachon and Menz, 2006). Furthermore, a high level of education among the general population may indicate a better capability by the administration to design new policies. Consequently, we expect that a *higher level of education will be positively correlated with adoption of policies to promote RE*.

Institutional factors

Institutional theories posit that the characteristics of the political system influence policy adoption. There is an extensive literature on the role of democracy for environmental protection. Congleton (1992) theorizes that authoritarian regimes will adopt less stringent environmental standards than democratic ones, as democratic regimes follow the preferences of the median voter, who benefits more from the public provision of environmental quality than the authoritarian ruler. Following a similar argument, Fredriksson (1997) and Deacon (2000) argue that democratic governments, being more inclusive and welfare-oriented, provide more environmental public goods than less democratic ones. While some literature has questioned this democracy-environment link (e.g. Midlarsky, 1998), newer studies such as those by Fredriksson and Gaston (2000), Neumayer (2002), Li and Reuveny (2006), as well as Bättig and Bernauer (2009) show that democracies tend to show stronger environmental commitment than non-democracies. We hence hypothesize that *the more democratic the government, the more likely it will adopt policies that support RE deployment*.

The institutional literature has also analyzed the effect of fractionalized political systems and of the number of veto players on policy adoption (Tsebelis, 1995, 1999), arguing that the more decision-making instances are involved in agreeing a new policy, the less able is a government to adopt the policy. These theories have also been applied to the study of environmental policy adoption, for example by Knill et al. (2010) and Ashworth et al. (2006). The attractiveness of this theory is that it is applicable to any type of political regime, not only to democracies, and is thus more applicable to developing countries. In accordance, we posit that *the more veto players within the political process, the less likely the government will adopt policies that support RE*.

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[70] The link between income and environmental quality is also made by the vast literature (e.g. Selden and Song, 1994; Roberts and Grimes, 1997; Narayan and Narayan, 2010) on the Environmental Kuznet Curve (EKC). This literature finds that environmental damage is positively related to increased income in case of poor countries, while the relationship becomes negative after a certain income threshold is reached. However, the empirical evidence on the EKC remains contested (Dinda, 2004; Stern, 2004), and the findings on environmental quality cannot directly be translated to our case of RE policy adoption: the EKC studies analyze environmental quality, not environmental policies. RE policy adoption may even grow when at the same time fossil-fuel energy use (as proxy for environmental damage) increases due to growth in poor countries. This theoretical reasoning is also confirmed by the non-significant impact of GDP^2 on policy adoption (see Annex 10.3.7)

Interest groups and preferences

On one hand, the strength of environmental groups has been positively linked with more or stronger environmental policy, including policies that support the deployment of RE energy (Fredriksson et al., 2005; Vachon and Menz, 2006) but, on the other hand, it can be argued that environmental groups sometimes lobby against specific RE investments that affect local environmental or social quality. Environmental groups may particularly oppose large hydro power projects, which may result in displacement of local populations and are thus opposed by environmental groups. However, large hydro power is usually not targeted by policies that support RE deployment, as it is a technology that is already competitive at current energy prices. Thus, we will expect that *countries with high presence of environmental (and civil society) groups will be more likely to adopt RE support policies.*

Ecological preferences of decision-makers and the public have been shown to be positively correlated with environmental policy-making (List and Sturm, 2006; Vachon and Menz, 2006; Knill et al., 2010). The rationale behind this is that a government of a population that generally cares about the environment can be expected to promote environmental policies, including the ones deploying more RE. We will hence expect that *in countries with high environmental preferences, the government will be more likely to adopt RE support policies.*

6.3.2 International determinants, including climate finance

Horizontal diffusion mechanisms

The policy diffusion literature draws from theories of organizational decision-making to assert that policy-makers look for ways to simplify their decision-making processes because capacity constraints prevent them from consulting all possible sources of information to find the best policy alternative. As a result, they look for solutions in other contexts (states or countries), where other policy-makers have faced similar problems and solved them successfully (Walker, 1969). Such *learning* – change in beliefs due to new evidence – or *emulation* – imitation due to socially constructed policy norms (Simmons et al., 2006) – is more likely to take place in case of neighboring countries, or countries within the same region (MacGarvie, 2005), because such peers are more likely to meet in common fora and exchange with each other (Berry and Berry, 2007). Following this literature, we hypothesize that the *adoption of a specific RE support policy will be more likely in a country if its neighbors have already adopted it.*

In addition, countries with cultural, historic or economic commonalities are also more likely to learn from each other (Simmons and Elkins, 2004) or even to compete for markets, e.g. for RE technology exports. Adoption of policies from culturally or historically similar countries can be understood as *learning* or *emulation* of peers "with psychological proximity", an idea based on constructivist theories, while adoption of policies from countries with similar economic structures may be a sign of *competition* (Simmons et al., 2006). Hence, we expect that the *adoption of a specific RE support policy will be more likely if countries with a common language, the same colonial history, or within the same economic and regional bloc have already adopted it.*

Vertical diffusion mechanisms

Apart from the three horizontal diffusion mechanisms of *competition* (with trade bloc partners), *learning* and *emulation* (from neighbors, regional and trade bloc partners and countries with similar culture and history) there is also a vertical diffusion mechanism: *coercion* by more powerful actors (Simmons et al., 2006; Dobbin et al., 2007; Shipan and Volden, 2008). Different types of coercion are physical force, the monopolization of information or expertise and the manipulation of economic costs and benefits (Dobbin et al., 2007). The last type, manipulation of economic costs and benefits, does not need to be coercive, so we may add financial *incentives* as additional diffusion mechanism. Both coercion and incentive mechanisms of diffusion have been found in research on state-level policy adoption in the US (Daley and Garand, 2005). At the international level, such top-down diffusion originating from a central government is missing but hegemonic countries (e.g. the US) may have coercive power (Dobbin et al., 2007). In the context of developing countries, the influence of former colonizers may be particularly relevant, as strong economic and political ties have remained after independence (Neumayer, 2003; Neumayer and Perkins, 2005; Albaugh, 2009). Therefore, we stipulate that the *adoption of RE policies will be more likely if the former colonizer has already adopted them.*

Vertical *coercion* or *incentives* may not only emerge from powerful countries but also from the global level. Studies have found that international agreements (Tews et al., 2003), international organizations (Edwards, 1997) and transnational networks at UN conferences (True and Mintrom, 2001) may influence national policies. As the international climate regime does not provide direct obligations for developing countries, and emission targets of transition countries under the Kyoto Protocol are not strict enough to require government actions, we expect that a direct signal from the signature of the UN Framework Convention or Kyoto Protocol on RE policies is relatively unlikely. However, developing countries may have reacted to more specific components of international climate policy that are targeted towards them. In the chapter before, we have seen that financial flows linked to the UN Framework Convention have supported different types of RE technologies, partly via financial incentives and capacity building for RE policy adoption. Therefore, we hypothesize that developing country governments may have reacted to the financial opportunity provided by the Clean Development Mechanism (CDM), see von Stein (2008), and to RE-related capacity building under development and environmental finance initiatives (Heggelund et al., 2005). While reacting to the CDM would imply a form of incentive-based policy diffusion mechanism such as the one observed by Welch and Thompson (1980) or Daley and Garand (2005), the effects of capacity building and technical assistance would rather resemble learning. We thus postulate that *developing countries with interest in participating in the CDM, or with RE-related projects under international environmental or development funding will more likely adopt policies that support* RE.

In case of European economies in transition, the European Union (EU) as international institution may both enable learning and use of coercive power, e.g. by imposing RE targets on all member states (REN21, 2007). Therefore, we assume that *the accession to the EU has a positive influence on adoption of RE policies.*

6.4 Empirical strategy and model

In the recent literature, the internal and external determinants of policy innovation are usually estimated by event history analysis, which can be used to model the changing probability over time that an event (in our case policy adoption) will take place, see also Schmitt et al. (2012). In the type of event history analysis applied here, we use discrete time (yearly) data and set the dependent variable (policy adoption) to 0 in all periods before adoption, to 1 in the period in which the policy is adopted, while excluding all countries from the dataset after the policy is adopted, as we are not interested in the presence but in the adoption of policies (Berry and Berry, 2007). This technique is also used by Matisoff and Edwards (2012). While it may be more difficult to identify the exact year of policy adoption in the past compared to identifying policies in the present year, the strategy of modeling "adoption per year" has the advantage that useful information on early versus late adopters and diffusion between countries can be contained[71].

We estimate the probability of policy adoption with a Logit model, a standard model used for estimating discrete-time event history models, using maximum likelihood techniques for estimation. We include time dummies to allow the data to determine the baseline hazard function in a non-parametric way rather than pre-determining it as would be the case when using a linear or any other trend (Tekle and Vermunt, 2010). Including country fixed effects is not possible as country dummies would predict non-success perfectly in case of countries where a policy is never adopted, so these countries would have to be excluded from the dataset.

6.5 Operationalization of variables and data

6.5.1 Dependent variables

As dependent variables we use dummies indicating the adoption year of each of the four RE support policies analyzed. The considered time span starts in the year 1998, as data on earlier adoption is not reliable, and ends in 2009. While we have some data for the years 2010 and 2011 (EBRD, 2011; IEA, 2011a; REN21, 2011b), an important source only included information up to 2009 (REEEP, 2011) so we restrict our dataset to the years where data is available from all sources. The variables were coded with the value of one in the adoption years as reported by the sources. If both the year of legislative decision and of entry into force were reported (e.g. IEA, 2011a), we used the year of entry into force to allow for comparability because the most important source (REN21, 2011b) just reported whether a policy is in place or not. If two sources reported different adoption years, we used the data from the sources with more contextual information (IEA, 2011a; REEEP, 2011).

6.5.2 Domestic determinants

Environmental factors

Domestic energy security: we proxy domestic energy security with a variable reflecting the generic energy independence (% of domestic energy that is produced in-country). This variable therefore captures both net energy imports (when the values are below 1) and net energy exports (when they are above 1). All data is sourced from EIA (2010). As additional measure for energy security, we would preferably also control for the average oil price in the relevant year, using data for the crude oil price from EIA (2011). However, as international energy prices only vary over time but not between countries, we can only test the influence of oil prices if we exclude the time fixed effects. Therefore, we will use models with oil prices only in the sensitivity analysis. In the sensitivity analysis, also the pump price for diesel fuel (USD per liter) in 2010 was included, using data from the World Bank (2012).

Air pollution: among all major air pollutants (SO_X, NO_X, PM_{10}, VOC, and NH_3), SO_X is the only one for which the power sector is the most important source: roughly 70% of SO_X emissions in Europe (EEA, 2012) and of SO_2 emissions in the US (EPA, 2012)[72] originate from electricity production. In South and

[71] Furthermore, modeling the presence of a policy in the current year does not solve the challenge that some policies are adopted by several legislative or governmental decisions that can be taking place in different years, so it may not be clear whether a policy is adopted in a specific year or not.

[72] The US EPA does only report SO_2 but no other SO_X emissions by sector.

East Asia, the share was similar in 2000 (EDGAR, 2012). We therefore measure electricity-related air pollution with metric tonnes of SO_2 per square meter of populated land area, using cross-sectional data of the year 2000 from EDGAR as reported in the Quality of Government dataset (QOG, 2012).

Natural resources: we use the same variables for geothermal, hydropower, wind and solar resources as in the chapter before.

Socio-economic factors

Level of income/wealth: the Gross Domestic Product (GDP) per capita is the usual way to measure the relative level of income and/or wealth (see e.g. Zarnikau, 2003; Sapat, 2004; Fredriksson et al., 2005; Vachon and Menz, 2006). We use power purchasing parity (PPP) figures for GDP to reflect the in-country value of the income, obtaining data from the World Bank (2011). The GDP level was standardized to 2007 US dollars using deflators from the OECD (2010b), and the logarithm was taken to improve the distribution of the variable. In addition to the level of income, we also include the GDP per capita growth in percentages to capture the influence of the change in income. As the level of income may not only have a direct influence on RE policy adoption (due to resources available for expensive RE technologies) but also an indirect one via energy consumption, we use the amount of electricity (in MWh) consumed per capita as control variable in one of the sensitivity analysis.

Level of education and population: the percentage of gross secondary school enrolment was taken as proxy for the level of education (World Bank, 2011), as data on tertiary education is only available for a limited amount of countries and years. For few country-year points, data was missing and we used linear interpolation to fill the gaps[73]. To control for overall size of a country, we included the logarithm of the population as further determinant, using data from the World Bank (2011).

Institutional factors

Democracy: all available indices for democracy over time have substantial drawbacks in conceptualization, measurement, and aggregation (Munck and Verkuilen, 2002), and only two (Polity and Freedom House Index) cover more than 150 countries and the time period 1995-2010. Of these two indicators with wide coverage, the Polity IV variable (Marshall et al., 2010) shows more advantages, e.g. inter-coder reliability, clear and detailed coding rules (Munck and Verkuilen, 2002) and is, therefore, taken as our indicator for democracy. Polity IV classifies countries from -10 (institutionalized autocracy) to 10 (institutionalized democracy), while the classification is based on five criteria: competitiveness of political participation, regulation of political participation, competitiveness of executive recruitment, openness of executive recruitment, and constraints on the chief executive.

Veto players: the number of veto players is taken from the Database of Political Institutions 2009 (updated March 2010), as contained in the Quality of Government database (QOG, 2012). The variable was first coded by Keefer and Stasavage (2003), is at minimum one, and further increases the more veto players are involved in legislative decision-making.

[73] We also tried including a more specific variable for RE-related knowledge based on international patent applications for renewable energy technology per applicant country, taken from the OECD (2012a). As this variable was never significant, we did not include it in the final specifications presented in the following.

Interest groups and preferences

Civil society and environmental groups: The strength of civil society is measured with the number of development civil society organizations in the year 2000 (Grimes, 2008). Environmental pressure groups are measured with the presence of Greenpeace members in a country (data from von Stein, 2008) and the number of environmental Non-Governmental Organizations as listed in Europa Publications (2000) and Hartley et al. (2009); data between 2000 and 2009 was linearly interpolated. For all variables except the Greenpeace dummy we used the natural logarithm to improve the distribution of the variable and take into account that the influence of NGO numbers probably has diseconomies of scale.

Environmental preferences: As we do not have a direct measure of ecological preferences for all countries included in our sample[74], we used dummies for the existence of a Green Party, their presence in national parliaments (Global Greens, 2012) and the terrestrial protected areas in % of total land area in the year 2008 (World Bank, 2011) as proxies.

6.5.3 International determinants, including international climate finance

Horizontal diffusion mechanisms (learning, emulation and competition)

To proxy diffusion mechanisms originating from learning from, emulating and competing with geographical, cultural and economic peers, we generate four variables that entail the percentage of peer countries that had already adopted the relevant policy in the previous time period. To construct the neighbor, common colonizer, and language variables, we use dyadic data from CEPII (2011) on land borders, common colonizers and on countries with a common language spoken by at least 9% of the population. For the regional trade blocs, we use memberships in regional and trade organizations as contained in the 2.3 version of the COW-2 International Organizations Dataset, originally coded by Pevehouse et al. (2004), taking the 2005 membership data (as proxy for the period 2000-2010)[75]. Each country was assigned to only one organization, e.g. all North African states were assigned to the Arab League but not to the African Union. A list of the regional and trade organizations coding is provided in Annex 10.3.1.

Vertical diffusion mechanisms (coercion, incentives and learning)

For measuring the influence of the former *colonizer*, we construct a variable containing the percentage of former colonizers (only post 1945 colonies) that have adopted the policy in the previous time period, using dyadic data from CEPII (2011). If countries have not existed in colonial times, the colonizer of the respective geographical area was taken. For the *Clean Development Mechanism* we use a measure for how many of the past three years (t-1, t-2, t-3) the country has been host of at least one registered CDM project involving RE. We can rule out potential endogeneity, given that CDM projects are already planned at least 1-2 years before registration[76] so it is very unlikely that their planning is influenced by policies adopted 2-5 years later. *International environmental funding* relevant for renewable energies mainly stems from the Global Environmental Facility (GEF), the operational entity of the UNFCCC financial mechanism since the early 1990s. We use data from GEF (2011a) on whether RE funding has been

[74] The World Values Survey does not cover all developing and emerging countries.

[75] We treated UNASUR (2012) members as one regional bloc even when it did not yet exist in 2005. However, in 2005 all of these countries except Guyana and Suriname were full or associate members of Mercosur.

[76] Historically, CDM projects have been registered on average 300-750 days after the start of the comment period (URC, 2012), when projects are already at an advanced planning stage.

approved in the previous 3 periods, as coded by Stadelmann (2009). For *international development funding*, we use a dummy on whether official development assistance entailing support for RE was committed for the relevant country in the previous three periods. The data for development assistance promoting RE was taken from the appendix to Michaelowa and Michaelowa (2011b). For measuring the effect of *EU membership*, a dummy variable was created taking on the value of 1 if the country was member of the EU in the respective year.

Table 16 provides an overview of all variables, their summary statistics and their expected influence. Given that we control for many covariates, we only have full data for 114 of the 163 countries in our dataset; data from other countries is excluded from Table 16. One limitation of the dataset is that for several variables only cross-sectional data is available. While in some cases this is not problematic as the average value should have an influence (e.g. geothermal, solar and wind potential), in other cases (e.g. civil society, pollution level) yearly values would be needed to reflect changes over time.

The specification of the variables, as summarized in Table 16, should help to avoid endogeneity due to simultaneity in the models: while many variables are clearly exogenous by themselves (e.g. natural resources, GDP, democracy, membership in organizations), others would potentially be endogenous (e.g. CDM, GEF, domestic energy, air pollution) but are specified as values in the past that should not be influenced by future policy adoption, so these variables should not be endogenous in a Logit model without country fixed effects.

Table 16: Overview of variables

Variable	Description	Sign	Source	N	Mean	SD	Min	Max
Target adoption	Adoption of renewable energy targets in specific year (dummy)		Own coding using data from EBRD, 2011; IEA, 2011b; REEEP, 2011; REN21, 2011b;	1119	0.04	0.20	0.0	1.0
Tariff adoption	Adoption of feed-in tariffs in specific year (dummy)			1137	0.03	0.17	0.0	1.0
Incentive adoption	Adoption of financial incentive for RE in specific year (dummy)			1143	0.03	0.18	0.0	1.0
Framework adoption	Adoption of framework policy for RE in specific year (dummy)			862	0.07	0.26	0.0	1.0
Domestic energy	% of energy consumption produced domestically, last year	-	EIA (2010)	1119	-0.65	1.89	-8.5	5.0
GDP per capita	Natural logarithm of GDP per capita in 2007 USD, PPP	+	World Bank (2011)	1119	8.28	1.16	5.6	11.3
GDP per capita growth	% growth in GDP per capita in 2007 USD, PPP (compared to last year	+	Calculated based on World Bank (2011)	1119	0.03	0.05	-0.2	0.6
Population	Natural logarithm of population	+	World Bank (2011)	1119	16.11	1.49	13.1	21.0
Education	% gross secondary school enrolment	+	World Bank (2011)	1119	0.61	0.29	0.1	1.2
Hydro resources	Natural logarithm of annual rainfall * average elevation	+/-	DWD/WZN (2010), Gallup et al. (2001)	1119	5.84	1.47	1.0	8.3
Wind resources	% of time wind speed is above 6 m/s, average over country area*	+	NASA(2011)	1119	18.48	13.51	0.1	52.9
Solar resources	Latitude tilt radiation in kWh/m^2/ day, average over country area*	+	NASA(2011)	1119	4.96	0.84	2.7	6.4
Geothermal resources	Number of volcanoes in the country*	+	Smithsonian Institution (2011)	1119	3.77	10.98	0.1	73.0
Biomass res.	Roundwood production in m^3 /capita	+	FAO (2012)	1119	0.77	1.11	0.0	7.9
Democracy	Polity IV index (10=full democracy, -10 = full autocracy)	+	Marshall et al. (2010)	1119	2.20	6.46	-10.0	10.0
Pollution	SO_2 emissions per square meters*	+/-	EDGAR (2012)	1119	3.97	13.84	0.0	131.0
Civil society organizations	Natural logarithm of development civil society organizations in 2000*	+	Grimes (2008)	1119	4.30	1.42	-2.3	6.6
Veto players	# of veto players in the country	-	QOG (2012)	1119	2.60	1.56	1.0	18.0
EU member	EU membership (dummy)	+	Own coding	1119	0.05	0.21	0.0	1.0
CEFTA	Membership in CEFTA (dummy)	+	Own coding	1119	0.04	0.20	0.0	1.0
Language	% countries with same language having adopted the policy one year ago	+	Own coding using CEPII (2011)	1119	0.11	0.15	0.0	1.0
Neighbors	% neighbor countries having adopted the policy one year ago	+	Own coding using CEPII (2011)	1119	0.12	0.22	0.0	1.0
Tradebloc	% of countries within the same bloc having adopted the policy one year ago	+	Based on Pevehouse et al. (2004)	1119	0.08	0.12	0.0	0.9
Colony	% of countries with same colonizer having adopted the policy a year ago	+	Own coding using CEPII (2011)	1119	0.07	0.11	0.0	0.4
CDM projects	CDM projects for RE registered in 3 previous years (dummy)	+	URC (2012)	1119	0.09	0.38	0.0	3.0
GEF funding	GEF grants for RE approved in 3 previous years (dummy)	+	Stadelmann (2009)	1119	0.11	0.31	0.0	1.0
Development aid	ODA grants for RE committed in 3 previous years (dummy)	+	Michaelowa and Michaelowa (2011b)	1119	0.56	0.50	0.0	1.0

* Only cross-sectional data (all other variables contain panel data)

6.6 Results

For each of the four types of policies in our dependent variables, we have estimated full models including all variables described above (see Annex 10.3.2 and 10.3.3) and parsimonious models only including variables that had a significant or almost significant impact in at least one of the full models (Table 17). There are only few changes when comparing full and parsimonious models. Any difference between full and parsimonious models will be mentioned when discussing the results.

Only in case of RE targets, the full 1119 observations could be used; in case of framework policies, only 864 observations are available for the dependent variable (see Table 15), as countries that have adopted a policy drop out of a dataset. In case of tariffs, and financial incentives, the year dummies leads to the loss of 1 years in case of tariffs and 2 years in case of incentives, as no policy was adopted in these years.

We conducted likelihood ratio tests to make sure that the excluded variables were not jointly statistically significant. The parsimonious models performed better in terms of the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) –, which assess maximum likelihood models both in terms of fit and parsimony[77]. In all models and for all independent variables, we report the marginal effects at the average value of all variables in the model, which makes it easier to understand the actual magnitude of the effect on RE policy adoption.

In general both domestic and international determinants are important for policy adoption but we find slightly more evidence for the relevance of domestic compared to international drivers, as shown by the model evaluation criteria for the separate international and domestic models[78].

6.6.1 Domestic determinants

Environmental factors

We hypothesized that energy insecurity and bad air quality would have a positive effect on RE policy adoption. In terms of energy insecurity, our findings show that the share of domestically-produced energy decreases the probability of FIT adoption and financial incentives, as expected. Furthermore, higher diesel prices significantly increase the chance of FIT adoption (see annex 10.3.7). Our indicator for air quality (SO_2) never displayed significant coefficients, which may be due to the fact that two opposing effects may be at play: while bad air quality may encourage governments to adopt policies that help to reduce air pollution, good air quality may be an indicator of an environmentally-friendly government that is more inclined to support RE policy.

In terms of natural resources, we find significant positive influence of wind resources on target adoption, and biomass and hydro resources on tariff adoption (all as expected), while we cannot observe similar effects for all the other combinations analyzed. In addition, hydrological resources seem to have the opposite impact than expected on the adoption of targets. We may explain this negative influence in two

[77] As alternative measure for fit of the models, the Pseudo-R^2 as displayed by STATA lies at 30% in case of targets, tariffs and incentives, while it is only at 17% in case of framework policies (see Table 17). However, the Pseudo-R^2 is less suitable for model comparison because it does not take into account parsimony as adjusted-R2 and AIC/BIC, and because for logistic regressions, there is not a generally accepted R^2 as for OLS, so it should only be interpreted with caution (IDRE, 2012).

[78] While the Pseudo-R2 and log-likelihood show more explanatory power for domestic determinants in case of all models, this may be partly because of more domestic variables in the model. If we look at AIC and BIC values that both incorporate fit and parsimony of models, the AIC always favors the domestic model, while generally BIC favors international model except for the case of targets (see Annex 10.3.4).

ways: First, renewable targets often exclude large-scale hydro power (REN21, 2011b). Second, countries with larger hydrological resources will already have a substantial share of RE. For them, setting a higher target is not very attractive as an increase in the share of RE will look tiny in public, while being financially costly. Two examples within Europe are the cases of Norway and Switzerland, which – despite being two of the wealthiest nations – have not adopted targets for the overall share for renewable electricity so far (REN21, 2011b).

In summary, we have some evidence that energy security concerns are driving decisions to support RE deployment in developing countries but we do not have evidence that air pollution has an effect, and having natural potential for producing RE does only in specific cases move developing country governments to adopt supportive policies.

Socio-economic factors

GDP per capita has a significant effect on the adoption of FITs and other financial incentives[79] but not for other policies, as predicted. There seems to be a direct effect of GDP on RE policy adoption, as the coefficient remains significant if we control for electricity consumption that accounts for the indirect effect[80]. We also expected to find a positive effect of education on RE policy adoption, but the positive coefficient is not significant in any of our full models so we excluded it from the concise ones. As our education variable is highly correlated with GDP per capita (see Annex 10.3.5), such a weak effect is not surprising. In contrast, the population, as measure for the size of a country has constantly positive influence on policy adoption.

Institutional factors

Our indicator for democracy is a significant predictor for adoption of feed-in tariffs and financial incentives – although in the parsimonious tariff model the coefficient is not significant –, while the coefficient is also positive but not significant in the other models. When replacing our indicator Polity IV with other democracy indicators – Freedom House and Bertelsmann Democracy Status –, we obtain similar results[81] and can, therefore, be quite confident that, in the case of RE financial incentives, Congleton's (1992) theory that democracies are more likely to adopt environmental regulation holds.

Veto players have no significant impact, although the expected negative coefficient is almost significant at the 10% level in case of financial incentives. A negative impact on financial incentives seems generally most reasonable among chosen policies as financial incentives involve more financial resources than targets and framework policies, so opposition from major political players is more likely, while in case of FITs, important veto players may be in favor (see Jacobsson and Lauber, 2006 for the case of Germany).

Interest groups and preferences

All the variables related to the potential effect of interest groups (civil society organizations, environmental NGOs) and environmental preferences (natural protected areas, green party existence) do not seem to have a significant effect on RE policy adoption, except for the adoption of framework policies, on which Green party representation in the parliament had a significant impact (see Annex 10.3.7). One limitation of this finding is that our indicators for interest groups and environmental

[79] The impact of income on incentives becomes insignificant in the full model.

[80] Electricity consumption has only an effect on RE policy adoption if GDP per capita is left out. Nevertheless, given the high correlation between the two variables, we cannot rule out that there is an indirect effect of GDP via electricity consumption.

[81] When using the Freedom House "Political rights" indicator, democracy even had a significant impact on target adoption.

preferences are sub-optimal; membership of environmental NGOs and environmental voting behavior of national parliaments would be preferable indicators but data is not available. Therefore, we cannot rule out that interest groups and governmental preferences are influential; we can just conclude that most indicators we used have no significant influence.

6.6.2 International determinants, including international climate finance

When turning to the international diffusion mechanisms, we never find a significant impact of policy adoption by neighbors, trade bloc partners, colonizing countries and countries with the same language[82]. In contrast, adoption by the former colonizer promotes targets (see Annex 10.3.6)[83], and adoption by countries that had the same colonizer has a significant impact on adoption of FITs, incentives and framework policies. Having the same colonial past may imply a similar regulatory culture that promotes policy diffusion, in the same way as the Walker regions (US states with similar regulatory history), see Matisoff and Edwards (2012). Membership to the EU proved to be an influential factor for adoption of targets and financial incentives. This underlines the institutional role of the EU as early mover in policies to promote RE and reduce greenhouse gases, and is in line with the policy convergence theories (Holzinger et al., 2008) and also with the findings by Schmitt et al. (2012) on air quality regulation.

With respect to the vertical channels of policy diffusion, the registration of CDM projects was irrelevant for all policies in the standard model except for target adoption, while the influence was also significant at the 10% level for framework policies if other lags for the CDM were used (see Annex 10.3.7). The potential influence on target setting and framework policies may relate to the positive signal of CDM project registration on the feasibility of more ambitious RE targets, while the clearly non-significant influence on financial incentives and tariffs may relate to the fear of developing countries that, after adoption of new incentive policies, their RE projects are not considered as "additional" to the BAU scenario any more, which would make them ineligible for CDM funding (Winkler, 2004). While such a perverse incentive of the CDM on policy adoption should not exist anymore after a 2004 decision of the CDM EB that domestic climate-friendly policies adopted after 2001 should not be considered when establishing the baseline of CDM projects (CDM EB, 2004), substantial uncertainty on the practical implementation of the new decision has remained, with recent heated debates in the case of wind and hydro power projects in China (He and Morse, 2010; Lewis, 2010).

In the end, the non-significant influence of CDM on adoption of FITs and other financial incentives, which are among the main RE promotion policies (Mendonça, 2007; REN21, 2011b), strengthens the finding in the last chapter that the CDM has limited influence on RE diffusion. If we had found a significant influence of the CDM on these RE policies, then the CDM would have an indirect influence on RE diffusion via policies. Therefore, the CDM EB's decision of not taking into account the effect of climate-friendly policies (e.g. RE policies) when evaluating CDM projects may have led to the registration of many projects where the CDM had neither a direct influence nor an indirect one via policies.

Funding from the Global Environment Facility seems to have, in the short term (first three years after GEF funding approval), a positive influence on adoption of framework policies, while the impact was

[82] Adoption by these peers also did not have an influence when we estimated separate models with only one peer adoption variable (language, colony, trade bloc or neighbor) included, see Annex 10.3.6. The only exception was incentive adoption that was significantly influenced by neighbor country adoption. Therefore, neighbors were included in the parsimonious model.

[83] The colonizer variable was not included in Table 1 (due to missing data on framework policy adoption by colonizers); the exclusion does not affect whether other variables are significant at the 10% level or not.

not significant for other policies. This result is consistent with the GEF's focus on capacity building and support for developing national RE strategies, roadmaps and standards, while direct financing is rather channelled through private intermediaries and not government policies (GEF, 2011c). However, we have to be cautious about concluding that GEF has been successful in driving framework policies in the short term as the GEF coefficient is quite sensitive to the model specification (e.g. the coefficient is not significant in the full model, see Annex 10.3.3). In the long term, we find a significant effect of GEF funding on targets and tariffs six years after funding approval (see Annex 10.3.5), which is consistent with the long-term capacity building approach under the GEF.

Development assistance (ODA) does not significantly increase the probability of policy adoption – only in case of FITs we find an influence that is almost significant at the 10% level. Given these unclear results on tariffs, more in-depth analysis may be needed to evaluate recent efforts of industrialized countries to replicate their successful tariff policies in developing countries, see e.g. GIZ (2012b, 2012a) for the case of German capacity building for FITs in South Africa and China.

Table 17: Logit estimations of the probability of policy adoption (parsimonious models)

	Targets		Feed-in-tariffs		Financial incentives		Framework policies	
	dy/dx	SE	dy/dx	SE	dy/dx	SE	dy/dx	SE
Domestic energy+	-0.001	(0.001)	-0.003	(0.001) **	-0.002	(0.001)	-0.004	(0.004)
GDP per capita	0.001	(0.002)	0.009	(0.004) **	0.009	(0.004) **	0.011	(0.008)
GDP growth	-0.041	(0.053)	0.006	(0.058)	0.055	(0.046)	-0.211	(0.152)
Population+	0.009	(0.002) ***	0.005	(0.002) **	0.008	(0.003) ***	0.018	(0.005) ***
Hydro resources	-0.005	(0.002) **	0.004	(0.002) *	0.002	(0.002)	-0.005	(0.004)
Wind resources	0.000	(0.000) **	0.000	(0.004)	0.000	(0.000)	0.000	(0.000)
Solar resources	-0.001	(0.003)	-0.005	(0.004)	0.005	(0.004)	-0.012	(0.010)
Geothermal res.	-0.000	(0.000)	-0.000	(0.000)	0.000	(0.000)	-0.000	(0.001)
Biomass res.	-0.002	(0.003)	0.004	(0.002) *	0.001	(0.002)	0.000	(0.007)
Democracy	0.001	(0.000)	0.001	(0.001) *	0.001	(0.000) *	0.002	(0.001)
Veto players	0.002	(0.001)	-0.001	(0.002)	-0.002	(0.001)	-0.001	(0.004)
EU member	0.032	(0.016) **	0.001	(0.012)	0.027	(0.014) **	-0.025	(0.049)
CEFTA	0.016	(0.009)	0.007	(0.009)	0.016	(0.009) *	0.030	(0.028)
Neighbours	0.011	(0.010)	-0.012	(0.011)	0.012	(0.009)	0.021	(0.023)
Colony	-0.003	(0.021)	0.050	(0.026) *	0.084	(0.039) **	0.073	(0.040) *
CDM projects	0.008	(0.004) *	-0.004	(0.004)	0.003	(0.004)	0.025	(0.018)
GEF funding	0.006	(0.005)	0.007	(0.005)	0.004	(0.004)	0.034	(0.018) *
Development aid	-0.004	(0.004)	0.009	(0.006)	0.007	(0.006)	0.009	(0.015)
Year FE	Yes		Yes		Yes		Yes	
N	1119		935		938		861	
Years	12		10		10		12	
log likelihood	-140.0		-112.1		-110.5		-185.9	
AIC	339.9		280.2		277.0		431.9	
BIC	490.5		415.8		412.6		574.6	
Pseudo-R^2	0.28		0.25		0.29		0.17	

dy/dx: Marginal effects at mean values of all other independent variables

SE: standard error

Significance levels: * = p-value of coefficient <0.1, ** = p-value <0.05, *** = p-value <0.01

+ For these variables the 2009 values have been extrapolated.

Our results are similar if we exclude economies in transition and focus on developing countries only. However, some coefficients become insignificant due to the smaller sample size (e.g. hydro has no impact on tariffs, and democracy no impact on incentives and tariffs any more) and the omission of EU countries.

The results remain similar if year fixed effects are excluded, and the oil price and the year are included as control variables, assuming a linearly increasing or decreasing baseline hazard over time[84].

6.7 Conclusions

In this article, we attempted to disentangle the drivers of the adoption of RE support policies in developing countries, considering both domestic factors and international diffusion mechanisms and four different types of RE policies.

Among domestic determinants, we distinguished between environmental, socio-economic, institutional and political-economic factors. Among international diffusion mechanisms, we distinguished between horizontal diffusion (emulation and competition among peers) and vertical diffusion (learning processes and incentives from international organizations and powerful nations). In general, we find support for both domestic and international drivers of policy adoption.

Among domestic factors, environmental factors and interest groups are only partly relevant for RE policy adoption. We find that the share of energy produced domestically, as a proxy for energy security, decreases the probability of promoting RE through FITs and financial incentives, while the level of environmental quality does not have a significant influence. Furthermore, we find some evidence that having natural hydrological potential decreases the probability of adopting RE targets, which often exclude traditional hydro power, while other renewable resources can increase the probability of policy adoption. Our indicators of interest groups – Greenpeace memberships, number of environmental NGOs, and other civil society groups – have no influence on RE policy adoption but given that these indicators are quite imperfect, further examinations may be needed. In case of indicators for environmental preferences, membership of green parties in parliaments has a significant influence on framework policy adoption.

In contrast to environmental factors, preferences and interest groups, we have strong evidence that socio-economic and institutional characteristics affect the probability of policy adoption. Countries with a higher income[85] and a larger population have a higher probability of adopting policies that support the deployment of RE, while a more democratic system promotes the adoption of financial incentives and FITs.

The finding that renewable energies are not primarily promoted because of environmental considerations, such as climate change, but more by socio-economic influences support the ideas of Winkler et al. (2007; 2008) and Sathaye et al. (2011), who argue that climate and RE policies should be integrated into national development policies and plans rather than pursued separately.

[84] We find a significant impact of the year variable but not of the oil price. This result is, however, not very robust as the correlation between the year and the oil price is very high (almost 0.9). When excluding the time variable, the coefficient on the oil price becomes positive and significant.

[85] It has to be noted that the positive effect of high income on RE policy adoption may be partly due to an indirect effect via higher energy demand. A higher energy demand will make adoption of RE policies more likely and, therefore, the question of "energy security" is probably more important than just measured by the influence of the share of domestically produced energy.

In terms of international policy diffusion, we have found little evidence for horizontal and vertical diffusion mechanisms. Our models estimate that only adoption by peers that had the same colonizer increases the likelihood of policy adoption, while adoption of a policy by neighbors, regional partners and countries with the same language has no influence. These results match with the findings from the US (Matisoff and Edwards, 2012), where adoption by neighbor states had no impact on RE policy adoption, while states with similar regulatory histories ("Walker regions") influence each other. Such diffusion among peers with similar colonial history may be related to established institutions or fora that that enable exchange, such as the Commonwealth (Leichter, 1983; Stone, 2000), or similar administrative and political systems (Gregg and Banks, 1965; Weiner, 1987; Weber et al., 2009) that may simplify emulation and learning. Case studies may help to understand these diffusion mechanisms in detail. Vertical channels of policy diffusion are also relevant. Membership to the EU increases adoption of RE policies.

We also find some evidence of influence by international climate finance: funding from the Global Environment Facility has, in the short term, positive effects on the adoption of framework policies but not of more specific support policies, while in the long-term (6 years after funding approval), a significant impact on targets and tariffs can be observed. These findings are in line with the primary role of the GEF as capacity building organization promoting long-term *learning processes*, while it lacks funding for substantial short-term incentives. Having CDM support for RE increases the adoption of RE targets and policy frameworks according to some model specifications, while it does clearly not affect the probability of adopting financial incentives and FITs. This is an important finding, given that CDM has also been discussed as *disincentive* for RE policy adoption (Winkler, 2004; He and Morse, 2010). The result also implies that further research may be needed on how the CDM may better promote national policies and whether international carbon market mechanisms at the sectoral or national level (Schmidt et al., 2008; Schneider and Cames, 2009) may be better suited in this regard.

The study has some limitations that show potential further areas of research. One limitation is that the distinction between domestic and international drivers is rather simplistic. In reality, domestic and international determinants may interact, e.g. the share of domestic energy is also dependent on the price and availability of international energy sources and the impact of international climate funding will depend on national institutions. Therefore, more qualitative work on the interplay between domestic and international actors and institutions may provide further insights. Such qualitative studies may also explore whether the effects of the EU and international climate finance rather relates to learning and emulation or to coercion and incentives.

Second, Walker's (1969) definition of first-time adoption of a policy within a country neglects the multi-step policy process, so further research may analyze the processes of adapting policies to the national context and of tightening or relaxing policies after first-time adoption (see Schmitt et al., 2012). Furthermore, it may be fruitful to use event history models also for the study of other climate policies in developing countries, such as climate change adaptation strategies and generic policies pledged under recent climate agreements.

7 Focusing on private finance mobilization – how does it influence the (cost-)effectiveness of climate finance in reducing greenhouse gases?

Abstract

In order to achieve the commitment to mobilize USD 100 billion to assist developing countries in coping with climate change by 2020, Northern governments call for increasing the mobilization of private finance. This study analyzes whether directing public finance towards projects mobilizing private finance is a cost-effective strategy to reduce greenhouse gas (GHG) emissions. In our theoretical analysis, we conclude that a focus on projects that mobilize most private finance will lower (cost-) effectiveness, if governments are well informed about (cost-)effectiveness of projects in reducing GHG emissions and already select the most (cost-)effective options. However, selection of private-finance-intensive projects may increase (cost-)effectiveness in case of non-informed policy-makers that are not able to select the most (cost-)effective projects. This thesis is confirmed by our empirical analysis of more than 300 projects in developing countries that are supported by climate finance: the projects with most private finance involved are different from those with the highest cost-effectiveness in reducing GHG emissions but there is a small positive correlation. In general, policy makers have to be cautious when subsidizing projects that claim to mobilize substantial private finance as high private finance numbers are a signal that projects may have happened without public support as well.

Keywords: Climate policy, developing countries, private finance, mitigation, cost-effectiveness

7.1 Introduction

In recent climate agreements (Copenhagen 2009, Cancun 2010), industrialized countries pledged to mobilize USD 100 billion of public and private resources for climate change mitigation and adaptation in developing countries. Politicians from industrialized countries request that the main part of the USD 100 billion should come from private sector sources. For example, both the EU (2011) and G20 (2011) have called for improving the mobilization ("leverage") of private finance. Similar calls can be found in studies written by funding institutions (Assmann et al., 2011; World Bank Group et al., 2011) and the grey literature (LSE, 2009; Ward, 2010; Brown and Jacobs, 2011). Even the CDM as climate policy instrument that is actually clearly focusing on GHG reductions, now highlights as first benefit the "USD 215.4 billion investment in CDM projects spurred by end of 2012" (UNFCCC, 2012). It seems that mobilizing private finance and investment has in a way become a climate policy objective in itself.

The academic literature has not yet studied the implications of a focus on mobilizing private finance in climate policy. While scholars generally agree that private finance is needed given its substantial share in overall investment capital (Lile et al., 1998; Zhang and Maruyama, 2001; Schmidt et al., 2008; Brinkman, 2009; Bowen, 2011; Olbrisch et al., 2011), the impact of mobilizing private finance on cost-effectiveness and effectiveness of climate policy has not yet been studied. This chapter addresses this literature gap on cost-effectiveness and effectiveness implications of private finance mobilization in climate policy.

Is there a theoretical argument why mobilizing private finance could *improve* cost-effectiveness and effectiveness of climate policy? One may suppose that private sector finance improves cost-effectiveness because implementation of public policy programs is in most cases found to be more cost-effective when the private sector is involved (Dunkerley, 1995; Estache, 2001; Mueller, 2003; Pattillo, 2006; Hodge and Greve, 2007). However, the calls in climate policy do not refer to private implementation but to private financing. In principle, a project may well be financed by the public sector and then implemented by the private sector – so these are different issues. Furthermore, the literature only finds a higher cost-effectiveness of the private sector when implementing *given (or similar) projects*. In practice, however, private finance might be targeting a *different basket of projects*. The targeting of different projects may have an effect on GHG emission reductions, which may go in the reverse direction.

Is there thus a theoretical argument why mobilizing private finance could in fact *decrease* cost-effectiveness and effectiveness of climate policy? Introducing mobilization of private finance as a new focus could create trade-offs for policy makers between the primary policy focus (maximizing GHG mitigation) and the secondary focus (mobilization of private finance). Such trade-offs could exist because the private sector has other priorities (e.g. profits, public relations) than climate change mitigation when investing in climate change programs[86]. Such other priorities will still exist if companies receive direct payments for GHG mitigation (e.g. in the carbon market), as they also receive other revenues than the ones for GHG mitigation, e.g. payments for electricity production or waste treatment.

Summing up, there are indeed theoretical reasons to assume that introducing the new focus of mobilizing private finance may rather decrease *cost-effectiveness* if climate policy makers are well informed, and – under the assumption that the private sector does not cover any mitigation costs – also reduce *effectiveness* of climate policy in mitigating climate change. To our knowledge, no study has analyzed this question so far, neither theoretically nor empirically.

[86] While also the public sector may have other priorities than public policy goals such as greenhouse gas emission reductions (e.g. being re-elected in case of politicians), this would not replace the trade-off between private finance mobilization and GHG reductions but add another trade-off for policy makers: the one between own interests and public policy goals.

This study will address this research gap by studying the case of international funding for climate change mitigation in developing countries, to which the call for mobilizing private finance mainly corresponds. We start off by defining the key terms (cost-effectiveness and private finance), followed by a detailed theoretical analysis under two situations (policy makers well and less informed about cost-effectiveness of projects in reducing GHG emissions), and an empirical application on 300 real world projects. We conclude that selecting climate change mitigation projects according to mobilization of private finance will decrease cost-effectiveness in case of informed governments, while it may improve it in the case of non-informed government. We finally discuss the results, including the implications for effectiveness, and explore different explanations why the public sector calls for private finance mobilization, even when it may result in less cost-effective and effective results. One of the most convincing explanations seems to be that policy makers have self-interests in mobilizing private finance, as they have to reach the USD 100 billion goal.

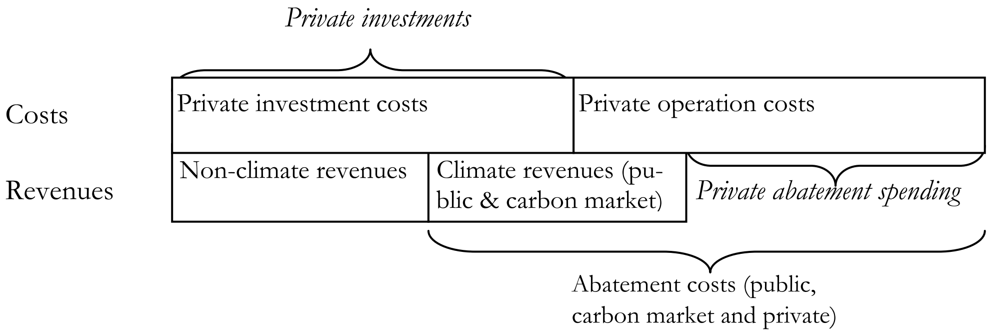
7.2 Theoretical analysis

For the theoretical analysis, clear definitions of the main terms ("cost-effectiveness" and "private finance") are required. Cost-effectiveness of international climate finance is defined in the same way as lined out in the introduction: the amount of greenhouse gas (GHG) emissions reduced per dollar of economic costs. Economic costs are more clearly defined here as abatement costs[87], so investment and operation costs minus the non-climate revenues of low-carbon interventions. For this chapter, we need the additional clarification that costs both encompass public and private costs, which is the standard definition of costs as applied by economists (see e.g. Mankiw, 2001).

Private finance can be defined in two ways (see Figure 19). The first definition of private finance is "private investments" or finance where the owner expects returns, a definition used in most calls for mobilization of private finance (see e.g. Assmann et al., 2011; EU, 2011). The second definition is "net private abatement spending", which we define here as "private investment and operation costs of a project minus non-climate revenues (e.g. selling of electricity) and climate revenues (e.g. public grants, grant-equivalence of concessional loans, tax breaks and revenues from the carbon market)". This second type, private abatement spending, includes private donations for climate change mitigation and investments where the investor is willing to accept a lower overall economic return because of the climate change mitigation benefits. The investor might take such choices because they can be indirectly beneficial for his image or because he personally values the environmental benefit (or both). However, this will certainly not be the general rule.

[87] "Abatement costs" are understood here as the absolute finance spent for abatement (USD), while in the literature the term "abatement costs" is also used for the finance spent per unit of abatement (USD per tCO_2)

Figure 19: Private funding understood as private investment and private abatement spending



For making figures comparable, all cost and revenue values are discounted to reflect values at the time of investment.

What is missing in Figure 19 (for simplicity) is that some of the investment costs may also be provided by publicly-owned companies expecting the same profits as private companies. Later in the empirical analysis, we will include public sector investments as control variable.

In the following, we analyze the decision-making process by a public institution (e.g. an international organization such as the GEF, or a national government agency), who has to decide how to spend a *given* budget for international climate change mitigation programs, assuming that there is a given basket of projects with fixed project features (e.g. volume of private finance, GHG mitigation, and costs). The analysis is split into two situations; in the first situation the government is well-informed about GHG mitigation (chapter 7.2.1), in the sense that it knows the programs that reduce GHG emissions most cost-effectively. In the second situation it is not well informed (chapter 7.2.2), in the sense that it does not know the cost-effectiveness of projects in mitigating climate change. In both situations, we assume that the government will try to achieve its public policy goals, no matter whether it is cost-effective GHG mitigation or private finance mobilization; if public institutions were putting more effort in one of these goals, our comparative analysis would not be possible.

7.2.1 Public institution is informed about cost-effectiveness in reducing GHG emissions

We look at scenarios with different policy goals. In scenario 1 the public institution has the goal of maximizing the cost-effectiveness in reducing GHG emissions. For this purpose it allocates funding, among a pre-defined basket of projects, to the projects reducing GHG emissions most cost-effectively. Under this scenario, private sector finance may be mobilized or not; the government does not care, it is just concerned about cost-effectiveness. In scenarios 2a and 2b, the public institution has a new goal: mobilizing private finance. Under scenario 2a, the public institution maximizes private sector finance and, by chance, the selected projects equal the projects reducing GHG emissions most cost-effectively. This scenario could apply if private sector profits and cost-effectiveness in reducing GHG emissions are perfectly correlated, or in a situation where the private sector is altruistic and prioritizes projects according to cost-effectiveness in reducing GHG emissions. Under scenario 2b, private sector finance is maximized but the projects selected are not the ones with most GHG emission reductions per USD. What happens to cost-effectiveness with if we move from scenario 1 (Reducing GHG emissions as policy goal) to scenarios 2a and 2b (mobilizing private finance as policy goal)? The impact depends on whether we see private finance as private investment or private abatement spending.

We first look at the case when private finance is defined as private abatement spending (Table 18). In scenario 1, the public institution chooses the projects maximizing GHG reduction per USD of abatement costs. If necessary, it will also include projects where the private sector takes over abatement costs (ac_{priv}) but it does not care about private abatement costs on its own. If scenario 2a applies, i.e. GHG emission reductions stay at the same level when the public institution switches from a cost-effectiveness to a private finance goal, then overall cost-effectiveness will stay equal as the public institution selects the same projects as in scenario 1, so both GHG emission reductions and abatement costs stay equal. In scenario 2b, where the new goal of maximizing private finance leads to less cost-effective projects, we see an increase in abatement spending as additional private sector abatement spending is mobilized. The mitigation of GHG can decrease as GHG emission reductions are lowered due to the shift to less cost-effective projects but they can also increase as more finance is spent for abatement, enabling more projects to be financed[88]. However, as we have assumed that already the most cost-effective projects have been selected in scenario 1, the net effect on cost-effectiveness in mitigating climate change is *by definition* negative.

Table 18: Cost-effectiveness when selection programs according to mobilized net private abatement spending

	Policy goal	Policy outcome	Abatement costs (=Abatement spending)	Effectiveness	Cost-effectiveness
Scenario 1	Maximizing cost-effectiveness	Cost-effective-ness maximized	$ac_{pub} + \mathrm{a}c_{priv}$	$GHG\searrow$	$\frac{GHG\searrow}{\mathrm{a}c_{pub} + \mathrm{a}c_{priv}}$
Scenario 2a	Mobilizing private finance	Cost-effective-ness maximized	$ac_{pub} + \mathrm{a}c_{priv}$	$GHG\searrow$	$\frac{GHG\searrow}{ac_{pub} + \mathrm{a}c_{priv}}$
Scenario 2b	Mobilizing private finance	Cost-effective-ness <u>not</u> maxim.	$ac_{pub} + \mathrm{a}c_{priv} + \mathrm{a}c_{priv+}$	$GHG\searrow \pm \Delta GHG\searrow$	$\frac{GHG\searrow \pm \Delta GHG\searrow}{ac_{pub} + \mathrm{a}c_{priv} + \mathrm{a}c_{priv+}}$
					$\left(< \frac{GHG\searrow}{ac_{pub} + \mathrm{a}c_{priv}}\right)$

ac = abatement costs; pub = public; priv = private; priv+= additional private costs in Scenario 2b; GHG↘ = GHG emission reductions; ΔGHG↘ = Change in GHG mitigation in Scenario 2b

In case of mobilization of investment costs (see Table 19) the public institution will maximize the GHG mitigation per USD of abatement costs in scenario 1. In scenario 2a, overall cost-effectiveness and effectiveness will stay equal as the public institution selects the same projects as in scenario 1. In scenario 2b, effectiveness in reducing GHG is lowered due to the shift to less cost-effective projects, while abatement spending is not increased, as the additional private finance mobilized only consists of investment costs and not abatement spending.

[88] This potential increase in cost-effectiveness actually assumes that the government does not achieve the maximization of GHG reductions in scenario 1, as it simply selects the most cost-effective projects and neglects some of the more costly projects where the private sector takes over abatement costs.

Table 19: Cost-effectiveness when selection programs according to mobilized private investment

	Policy goal	Policy outcome	Abatement costs (=Abatement spending)	Effectiveness	Cost-effectiveness
Scenario 1	Maximizing cost-effectiveness	Cost-effective-ness maximized	$ac_{pub} + \mathrm{ac}_{priv}$	$GHG{\searrow}$	$\frac{GHG{\searrow}}{\mathrm{ac}_{pub} + ac_{priv}}$
Scenario 2a	Mobilizing private finance	Cost-effective-ness maximized	$ac_{pub} + \mathrm{ac}_{priv}$	$GHG{\searrow}$	$\frac{GHG{\searrow}}{ac_{pub} + \mathrm{ac}_{priv}}$
Scenario 2b	Mobilizing private finance	Cost-effective-ness <u>not</u> maxim.	$ac_{pub} + \mathrm{ac}_{priv}$	$GHG{\searrow} - \Delta GHG{\searrow}$	$\frac{GHG{\searrow} - \Delta GHG{\searrow}}{ac_{pub} + \mathrm{ac}_{priv}}$ $\left(< \frac{GHG{\searrow}}{ac_{pub} + \mathrm{ac}_{priv}} \right)$

ac = abatement costs; pub = public; priv = private; GHG↘ = GHG mitigation, ΔGHG↘ = Change in GHG mitigation in Scenario 2b (GHG mitigation will always decrease)

The analysis has shown that, under a situation of a well-informed public institution, mobilization of private finance as new policy goal will either mean equal cost-effectiveness (scenario 2a) or decreased cost-effectiveness (scenario 2b). This conclusion is the same for mobilizing private abatement spending (Table 17) and profit-oriented private investments (Table 18).

For effectiveness in reducing GHG emissions, mobilizing private finance either implies equal effectiveness (scenario 2a), decreased effectiveness (scenario 2b, when profit-oriented private investment is mobilized) or either an increase or decrease in effectiveness (scenario 2b, when private abatement spending is mobilized).

Now, how reasonable is scenario 2a, where cost-effectiveness is still maximized after switching to the goal of private finance mobilization, compared to scenario 2b, where cost-effectiveness is not any more maximized? In case of *mobilizing private abatement spending,* scenario 2a will only occur if the most cost-effective projects are the same as the projects that maximize private abatement spending. This is, however, quite unlikely as private sector players who are willing to take over abatement costs (e.g. NGOs or companies caring about climate change) will often but not always select the most cost-effective options; in some cases, they will pay for GHG abatement in projects within their own industry, or in technologies where they want to enter into the market (e.g. solar energy), which will not necessarily be the most cost-effective programs. In case of *mobilizing private investment,* scenario 2a is only occurring in the improbable case that project selection according to the level of private investment (Scenario 2) is the same as selection according to cost-effectiveness in mitigating GHG emissions (Scenario 1). There are many reasons why the most cost-effective projects may not be the same as the private investment maximizing projects, e.g. non-climate revenues leading to high investment intensities in energy projects and public sector control of important production sectors in some developing countries. It thus appears that scenario 2b should be much more likely to occur.

We therefore obtain the result that, assuming the public institution is well-informed about GHG mitigation, the goal of mobilization of private finance cannot increase cost-effectiveness of climate policy compared to the situation where the goal of the public institution is to maximize cost-effectiveness. It is even likely that cost-effectiveness decreases as private finance and cost-effectiveness will hardly ever be perfectly correlated. Therefore, we hypothesize that *under a situation where the public institution is already well informed about GHG mitigation, mobilizing private finance will decrease cost-effectiveness (hypothesis 1).*

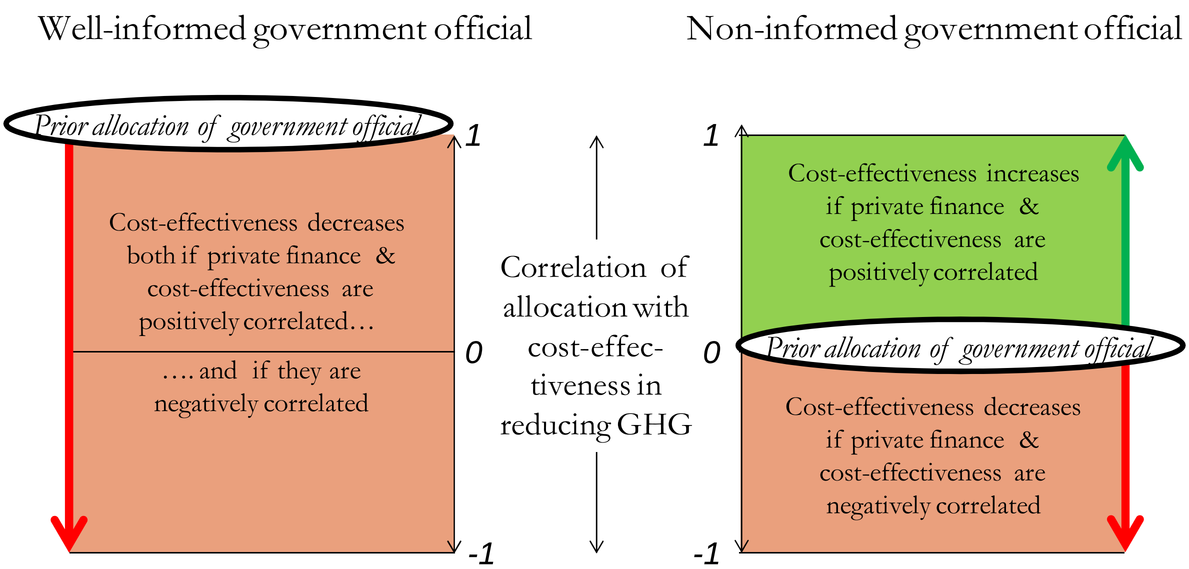
The theoretical discussion also reveals that, in case of well-informed public institutions, mobilizing private finance can only increase effectiveness in reducing GHG emissions if the mobilized private finance covers abatement costs, and if this additional private abatement spending can compensate the losses in GHG reduction due to the shift to less cost-effective projects. If the mobilized private investment simply consists of private investment, then effectiveness in reducing GHG emissions will tend to decrease when private finance is maximized. In the following, we will test the theoretical ideas on cost-effectiveness and discuss the implications of our empirical findings on effectiveness at the end of the paper.

7.2.2 *Public institution is not informed about cost-effectiveness in reducing GHG emissions*

As we have seen, the new policy goal of mobilizing private finance cannot improve cost-effectiveness in a scenario where the public institution is well-informed. The reason is that a well-informed public institution will select the most cost-effective projects, so the correlation between his project ranking and the cost-effectiveness of projects in reducing GHG emissions is perfect (or 1 if expressed as a correlation coefficient). In such a situation, a new selection according to private finance will always reduce cost-effectiveness as long as private finance and cost-effectiveness do not perfectly correlate (see Figure 20 left).

The situation is different if a public institution is not informed about cost-effectiveness (see Figure 20 right). In such a case, the public institution will have to randomly select projects as it has no knowledge about projects provide GHG mitigation most cost-effectively, so the expected correlation between his selection and cost-effectiveness in reducing GHG emissions is zero. Now, a goal of mobilizing private finance may become useful if there is a positive correlation between private finance and GHG mitigation[89].

Figure 20: Cost-effectiveness impact when shifting policy goal from cost-effectiveness to private finance



[89] It is clear that the two situations of fully informed and fully informed public institutions are extreme cases, the reality will be somewhere between these situations.

Can we expect private finance to be positively correlated with cost-effectiveness in reducing GHG emissions? On one hand, there may be a positive correlation as the private sector may more efficiently finance projects compared to public funding institutions. Furthermore, if implementation and finance are linked, privately financed projects may benefit from efficient implementation by the private sector (see literature review of Mueller, 2003). On the other hand, there may be a non-significant correlation as the private sector primarily follows profit expectations and will, therefore, have other investment priorities than investments leading to more greenhouse gas emission reductions[90]. As the potentially non-significant impact is based on different investment priorities, we can assume that, *under a scenario where public institutions have no information on cost-effectiveness, mobilizing private finance has a positive influence on cost-effectiveness if similar project types are compared (hypothesis 2).*

7.3 Empirical analysis of international climate financing

From our theoretical analysis we have derived two main hypotheses. First, if the public institution is informed about cost-effectiveness, then funding allocation according to mobilization of private finance can be expected to lower cost-effectiveness. Second, if the public institution is not informed then project selection according to private finance has a positive influence on cost-effectiveness if similar investment projects are compared.

We will test these theoretical hypotheses by carrying out an empirical analysis of more than 300 real-world climate change mitigation projects supported by international climate finance. The projects stem from a sample of projects supported by the Clean Development Mechanism (CDM) and the Global Environment Facility (GEF). The CDM and GEF were selected because of availability of data on GHG reduction and private finance in their project documents, the wide range of policy instruments applied, and the direct link to the UNFCCC.

At first sight, the use of CDM data for analyzing climate finance allocation by the public sector is surprising, as the CDM is mostly referred to as carbon market instrument. However, the analysis of CDM data makes sense because of at least three reasons. First, CDM data covers most GHG mitigation areas, is of very high quality as it is verified, and most importantly it is publicly available. Second, the CDM credit (and therefore CDM funding) allocation is governed by public sector institutions, the CDM Executive Board and the UNFCCC COP. These public institutions could theoretically decide to allocate CDM credits not according to GHG emission reductions, but according to other goals, such as sustainable development or mobilized private investments. Third, public institutions (e.g. the World Bank and industrialized country governments) are major buyers of carbon credits, so these public institutions could decide to buy only credits from projects that mobilize substantial private investments. Summing up, analyzing CDM data is both useful because of the high quality of publicly available data, and the role of public institutions in determining to which projects the CDM funding should flow.

We select a sample of 101 GEF-supported and 224 CDM-supported projects. The 101 analyzed GEF-supported projects have been selected randomly and represent more than half of all projects with disbursements until the end of 2008. The sample mean does not significantly differ from the whole population in terms of approval year, project size or share of RE projects (95% confidence interval). The CDM sample is based on data from Castro (2012) and is considered as representative regarding project types as it covers projects from all 21 CDM project types (URC classification) with at least 0.2% of

[90] If the government initiates a substantial carbon price (e.g. through a carbon tax or an emission trading scheme), private investments would more strongly correlate with CO_2 emission reductions in general. However, we do not consider here projects that are already profitable because of other government interventions, as these projects do not need further support.

credits expected by 2012. The only major project type excluded is HFC, for which investment data is not available in project documents due to confidentiality, and where investment data in the literature (e.g. Wara, 2008) are not verified. The sample includes projects from 29 countries, which host 99.8% of all CDM-supported projects registered by the end of 2010 (URC, 2011)[91]. Data for the 224 CDM-supported projects is taken from Castro (2012) but non-registered projects and the ones with missing investment data are excluded. Castro (2012) actually uses 28 types but we merged the different sub-types of biomass, landfill, methane and N_2O projects into 4 main project types (biomass, landfill, methane and N_2O). Furthermore, we updated some information, using the newest project documents from UNFCCC (2011f).

The analysis is based on data from both ex-ante project documents and evaluation documents. As evaluation documents, we use terminal evaluations in case of the GEF and verified monitoring reports in case of the CDM. While we have only evaluation data for 42 GEF and 68 CDM projects, data quality may be higher as cost-effectiveness is not only projected but really evaluated. 6 of the 224 CDM projects had negative abatement costs and where, therefore, excluded in all steps, as the cost-effectiveness of financing these projects is difficult to analyze: if these projects are only undertaken because of additional climate change support, the support is very cost-effective; in contrast, if these projects would also be undertaken without climate change, then the support is very cost-ineffective as no additional GHG emission reductions are generated. We will return to this problem when discussing the results.

The empirical analysis is conducted in two steps. In a first step, correlation coefficients are calculated between cost-effectiveness in reducing GHG emissions and mobilizing private finance. This step will help to see whether the correlation is indeed below 1 and, therefore, mobilizing private finance will lead to lower cost-effectiveness in case of a well-informed public institution, as we have postulated in the first hypothesis. The correlation analysis will also help to see whether mobilizing private finance improves cost-effectiveness in case of a non-informed public institution. In a second step we will control for other determinants of cost-effectiveness in reducing GHG emissions (see chapter 5), in order to see whether there is indeed a positive relationship between private finance and GHG mitigation when we compare "similar investment projects", so focusing on private investment mobilization will improve cost-effectiveness in case of non-informed public institutions, as postulated under the second hypothesis.

7.4 Empirical analysis I: Correlation of private finance and cost-effectiveness

For the first part of the empirical analysis, we use both Pearson's correlation coefficient and Spearman's rank-ordered correlation coefficient. Pearsons' coefficient is the usual coefficient used for continuous variables. However, it is quite sensitive to outliers, so we apply also the Spearman's rank-ordered correlation coefficient to check robustness of our results.

7.4.1 Operationalization of variables and data

For the correlation analysis, we have to operationalize the two concepts of cost-effectiveness and private finance. For cost-effectiveness, we have to operationalize both GHG mitigation and abatement costs.

[91] However, the sample is not fully representative of the countries involved, as some countries are underrepresented (India, Brazil), while others (Malaysia and South Korea) are over-represented.

GHG mitigation

In case of the CDM, GHG mitigation was accounted for in the first crediting period, so in the first 7 to 10 years after project start. This is a different operationalization as in chapter 5 where we accounted for lifetime of projects, which is not possible here, as technology lifetimes are not available for all technologies in the dataset[92]. In case of the GEF, GHG mitigation was accounted during the different lifetime of applied technologies – 5 to 50 years. The GEF operationalization is the same as in chapter 5. We refrain from standardization of GHG reduction years as this would distort the results in favor of short-term mitigation measures. As CDM crediting period and GEF technology lifetimes are not fully comparable and data is of different quality, we will keep CDM and GEF analysis separated. For GHG mitigation at the evaluation stage, we use the numbers as contained in terminal evaluation documents (source: GEF, 2011a) for GEF, while we multiply the amount of expected GHG emissions reductions of CDM projects with the % of credit issuance success until July 2012 for, as reported by URC (2012). Because of their rather speculative nature, we excluded GEF estimations for "indirect emission reductions" expected from capacity building and policy change. While the quality of CDM data was sufficient due to the detailed accounting methodologies applied, the GEF data often had to be transformed by assuming the same lifetime per same technology and the same GHG emission factor per fuel. Furthermore, all costs from both GEF and CDM were transformed to constant 2009 USD, using deflators from the OECD (2010b).

Abatement costs

In the case of the CDM, abatement costs are investment and operation costs minus non-CDM revenue, all of which are discounted according to discount rates found in the project documents. In the case of the GEF, abatement costs are assumed to be equal to GEF grants as the GEF policy is to only finance incremental costs, so the GEF should not pay for non-climate related costs, which are to be covered by development or other co-finance.

Private finance

For private finance we use private investment costs, so our first definition of private finance. We do not use the second definition of private finance (private abatement spending) here because of two reasons. First, we only have data on private investment but not on private abatement spending. Secondly, only using one definition can also be justified as our theoretical analysis suggests that maximizing private finance will lower cost-effectiveness (compared to the case where a well-informed public institution allocates funding according to the projects reducing GHG emissions most cost-effectively), no matter which of the two definitions of climate finance we use. For standardization, private investments are divided by the amount of climate finance (GEF or CDM payments) needed to mobilize these investments. In case of GEF, this amount of climate finance equals GEF grants, while in case of CDM, this amount equals abatement costs (and not total CDM payments). By this standardization, the private finance variable is equal to the amount of private finance that can be mobilized per unit of public sector funding, which is what some recent studies call the "leverage ratio", which they want to maximize.

As some project investors are publicly owned, we had to separate public and private investment. In case of GEF, project documents separate between public and private investment in most cases; in a few cases the internet had to be consulted on whether an investor is publicly or privately owned. In case of the CDM, the host country project participant was taken as proxy for the investor. Then the public or

[92] Using technology lifetimes (and crediting periods in cases where no technology lifetimes were available) instead of crediting periods, the results did not differ substantially (same sign and significance of coefficients at 90% confidence level).

private ownership of the CDM project participant was identified using information in the project documents and on the internet.

If not noted differently, all data – GHG mitigation in tonnes CO_2-equivalent, abatement costs in USD and private investment costs – were taken from the CDM and GEF project documents available on their official websites (GEF, 2011a; UNFCCC, 2011f).

7.4.2 Data overview

The summary statistics for the GEF and CDM data we use for the analysis are presented in Table 20. The mean cost-effectiveness of GEF and CDM are not comparable here as the mechanisms do not use the same project lifetimes, and the depth of GHG calculations is more advanced in case of CDM (see chapter 5). For the analysis, standardization of project lifetimes is not needed as the analysis for CDM and GEF is conducted separately.

Table 20: Summary statistics of project-level data from the GEF and the CDM (main variables)

Variable	Description	Obs	Mean	SD	Min	Max
GEF						
Cost-effectiveness (PD)	tCO_2eq reduced/GEF grant in USD, project doc. (PD)	101	0.79	1.90	0.00	14.51
Ln cost-effectiveness (PD)	ln of tCO_2eq reduced/GEF grant in USD, PD	89	-1.70	1.95	-6.75	2.67
Cost-effectiveness (EV)	tCO_2eq reduced/GEF grant in USD , evaluations (EV)	43	0.92	2.31	0.00	13.26
Ln cost-effectiveness (EV)	ln of tCO_2eq reduced/GEF grant in USD, EV	40	-2.05	2.55	-8.51	2.58
Private investments	Private investments/ GEF grant	101	1.62	2.39	0.00	12.87
CDM						
Cost-effectiveness	tCO_2eq reduced/ abatement costs in USD, PD	224	0.47	0.78	-0.76	4.85
Ln cost-effectiveness	ln of tCO_2eq reduced/abatement costs in USD, PD	218	-1.64	1.64	-7.31	1.58
Cost-effectiveness (EV)	tCO_2eq reduced/abatement costs in USD, EV	68	0.32	0.77	0.00	5.90
Ln cost-effectiveness (EV)	ln of tCO_2eq reduced/abatement costs in USD, EV	68	-2.26	1.75	-7.45	1.78
Private investments	Private investments/CDM payments needed to cover abatement costs	224	2.02	3.57	-7.30	17.12

Source: online project documents of GEF (GEF, 2011c) and CDM (UNFCCC, 2011f). CDM cost-effectiveness data is from Castro (2010)
USD = 2009 constant USD, ln = natural logarithm, PD = Project documents, SD = Standard deviation, EV = evaluations

7.4.3 Correlation results

Table 4 shows the correlation results for the GEF-supported projects. Private investments are significantly and positively correlated with the natural logarithm of cost-effectiveness, both in case of the Pearson's product-moment correlation coefficient (Table 21 left) and the Spearman's rank-ordered pair-wise correlation coefficient (Table 21 right)[93]. However, correlations between private investments and

[93] The logarithm is taken as this is the value used in the regression results (where a good distribution of the dependent variable is advantageous). If pure cost-effectiveness values and not the logarithm are taken, then the coefficients are by definition the same in case of the Spearman's coefficient or similar in case of the Pearson's coefficient (see annexes 10.4.2 and 10.4.3)

cost-effectiveness are far from 1. In terms of our hypotheses, hence, this would mean that funding allocation according to mobilized private finance would indeed substantially decrease cost-effectiveness in mitigating GHG, if the public institution is well informed and would otherwise select the most cost-effective projects. However, allocation according to private finance may slightly improve cost-effectiveness if the public institution is non-informed about GHG mitigation, and would, therefore, otherwise not know which projects to select.

Table 21: Correlation between private investment intensity and cost-effectiveness of GEF-supported projects (PD data)

	Pearson's pair-wise correlation coefficient	Spearman's rank-ordered pair-wise correlation coefficient
	Ln cost-effectiveness (PD) GEF	Ln cost-effectiveness (PD) GEF
Private investments	0.20*	0.23**

N=89
* = p-value <0.1, ** = p-value <0.05, *** = p-value <0.01

Also in case of the CDM, there is a positive correlation between private investment intensity and the natural logarithm of cost-effectiveness, and the correlation is even highly significant for both the Pearson and the Spearman's rank-ordered coefficient (see Table 22)[93]. However, as the coefficients are far from 1, we would see a decrease in cost-effectiveness when switching from project selection according to climate change mitigation to selection according to mobilized private finance, if we assume a well-informed public institution.

Table 22: Correlation between private investment intensity and cost-effectiveness of CDM-supported projects (PD data)

	Pearson's pair-wise correlation coefficient	Spearman's rank-ordered pair-wise correlation coefficient
	Ln cost-effectiveness (PD) CDM	Ln cost-effectiveness (PD) CDM
Private investments	0.20***	0.19***

N=218
* = p-value <0.1, ** = p-value <0.05, *** = p-value <0.01

The correlation results from both the CDM and the GEF nurture our theoretical assumptions that selecting programs according to private investment intensity will decrease cost-effectiveness of climate policy if public institutions are well informed, while it may increase cost-effectiveness if they are not informed at all and would select programs randomly in the absence of the private investment indicator. If public institutions are partly informed, then private investment intensity as allocation criterion will only improve cost-effectiveness if the correlation coefficient of their own project ranking with cost-effectiveness is lower than the correlation coefficient of private investment intensity with cost-effectiveness (0.2 in both our CDM and GEF sample). Therefore, only a poorly informed public institution will improve cost-effectiveness of his funding allocation when switching to private finance mobilization as allocation criteria.

7.5 Empirical analysis II: Controlling for other determinants of cost-effectiveness

The downside of a simple correlation analysis is that the link between private finance and mitigation cost-effectiveness may be either overestimated or underestimated because further determinants influence cost-effectiveness. In addition, we do not really compare "similar investment projects", which we need for testing the second hypothesis ("in case of a non-informed public institution, private finance has a positive influence on cost-effectiveness if similar investment projects are compared"). Therefore, as second step, we conduct ordinary least-square regression that analyzes which part of the variation in cost-effectiveness of projects can be explained by private investments, after controlling for other determinants. Such an analysis will show the average impact of private investments on cost-effectiveness when comparing similar projects, and will also enable us to see whether we find better indicators for cost-effectiveness than private investments.

7.5.1 Determinants of cost-effectiveness according to the literature

For modeling the "similar investment projects", the features of investment projects that may have an influence on cost-effectiveness have to be specified. From the literature we derive that the following variables may be relevant determinants of cost-effectiveness: project type, size of the economy, project size, time, implementing entity, non-climate public grants and public investments.

Project type: Cost-effectiveness varies a lot between climate change mitigation project types, both in theory according to marginal abatement cost studies (Criqui et al., 1999; Klepper and Peterson, 2006; Kuik et al., 2009) as well as in practice, see the case of carbon markets (Castro, 2012) and public finance (Stadelmann, 2009). Thus, the project type may have a significant influence on cost-effectiveness of climate change mitigation projects.

Size of the economy: in case of the GEF where only governments can access funding, larger economies can be expected to have higher bureaucratic and economic resources, and can therefore submit more elaborated projects. However, larger economies may also be able to afford less cost-effective projects because of substantial own resources.

Project size: larger projects may benefit from economies of scale, which are given if an increase in the levels of all input factors can lead to more than proportional increases in the levels of outputs produced (Panzar and Willig, 1977). Economies of scale are a standard assumption or finding in climate and energy policy (Ironmonger et al., 1995; Neij, 1997; Jacobsson and Johnson, 2000; Ryan et al., 2006), while examples of diseconomies of scale are rather rare (e.g. Isoard and Soria, 2001).

Timing: it is reasonable that countries and project developers first implement the least cost projects. This issue has been discussed as the low-hanging fruit phenomenon in the carbon market (Narain and van't Veld, 2008) and the empirical evidence shows that the phenomenon occurs in a limited way (Castro, 2012). Yet, cost-effectiveness may also improve over time as learning improves cost-effectiveness of renewable energies over time (see Junginger et al., 2005; Nemet, 2006).

Implementing entities: Given the relevant role of different implementing entities in case of GEF, it seems to be warranted to control for the entity that implements GEF projects.

Public grants for non-climate purposes: some climate change projects also receive grants from development agencies and developing country governments. Such grants are not considered as part of abatement costs, as they have other aims than climate change, e.g. health or energy security. Such grants may both enhance cost-effectiveness as synergies between other goals and climate funding can be harvested (e.g. in the case of renewable energies that are also contributing to energy independence) and project size is increased, but it can also decrease cost-effectiveness as these grants have other goals than climate change mitigation.

Public investment: as mentioned above, in many countries public or publicly-owned investors are also important for providing equity and debt financing. Furthermore, MDBs provide loans for climate change mitigation projects (see e.g. Martinot, 2001), which may influence cost-effectiveness of investments.

To ensure that we measure the influence of private investment intensity on cost-effectiveness, we control for all these variables.

7.5.2 Operationalization of variables and data

Cost-effectiveness and private finance are operationalized in the same way as in the correlation analysis before. We use the natural logarithm of cost-effectiveness in reducing GHG emissions, measured in tonnes of CO_2-equivalents per USD (*lnCO2pUSD*), as dependent variable because the logarithmic form fits a normal distribution much better than the non-logarithmic version (see Annex 10.4.1). Unfortunately, taking the logarithm excludes the 12 GEF projects with zero cost-effectiveness (zero GHG impact). The other determinants identified in the literature are operationalized as follows;

Project type: For the CDM, dummies are created for all project types included in the URC database on CDM projects (URC, 2011). For GEF projects (GEF, 2011a), the same project types are used and two additional project types – mix of renewable energies and mix of RE and energy efficiency – are added because some projects include several technologies.

Size of the economy: We include the total GDP of the host country in the approval year (in constant 2009 USD) as proxy for the size of the economy, using data from the World Bank (2011).

Size of project: As proxy for project size, we use expected annual carbon credits in the first crediting period for CDM projects (URC, 2011) and the grant in USD for GEF projects (GEF, 2011a). As expected CDM credits are a proxy for climate revenues, it is comparable to GEF grants. In case of the GEF, GHG mitigation would not be a good approximation for the project size as some projects directly invest in emission reduction activities while others promote capacity building and have hardly any direct GHG impact.

Date of approval: For the CDM, we take the year of registration as proxy for approval time, while in the GEF case, the year of CEO acceptance is used, which is in GEF terminology the "CEO endorsement" for full size projects and "CEO approval" for medium size projects. These years represent the approximate date of the project documents we analyzed.

Implementing entity: In case of the GEF, supported projects are implemented by international organizations (Heggelund et al., 2005; Mee et al., 2008), in our sample UNDP or the World Bank. Therefore, we included a dummy for the World Bank to control for potential differences between public implementing entities. Lindholt (2005) argues that the World Bank should be more efficient than UN organizations.

Public grants for non-climate purposes: In case of the CDM, we do not control for non-climate public grants as the information is not available in project documents. Furthermore, development assistance should only play a minor role in the financing of CDM projects due to a UNFCCC (2001) decision that public funding for CDM projects should not divert Official Development Assistance and OECD (2004) rules that funding for CDM credits cannot be counted as Official Development Assistance. In case of the GEF, we control for international grants per USD of GEF grant and national grants per USD of GEF grant, using information in project documents (GEF, 2011a).

Public investment: In case of the CDM, public investment intensity is calculated as investment costs of projects with a publicly-owned project participant divided by CDM payments needed to cover abatement costs. In case of the GEF, investments of national or international publicly-owned institutions are divided by GEF grants. Information on costs and ownership is taken from project documents (GEF, 2011a; UNFCCC, 2011f) and supplemented by internet information in case public or private ownership of investors was not visible in project documents.

7.5.3 Data overview

We use the same sample of 101 GEF-supported and 242 CDM-supported projects as in the correlation analysis before. The summary statistics for the data we use for the regression analysis are presented in Table 23 (project type dummies are not shown; for the data on private finance and cost-effectiveness, see Table 20).

Table 23: Summary statistics of project-level data from the GEF and the CDM (control variables)

Variable	Description	Obs	Mean	SD	Min	Max
GEF						
World Bank	Dummy (=1 if World Bank implementing)	101	0.51	0.50	0.00	1.00
Size of the economy	GDP of the country in billion 2000 USD	101	265	445	0.46	1908
Size of project	GEF grant (million 2009USD)	101	6.66	8.74	0.38	49.80
Date of approval	Year of approval, deviation from 1990	101	9.51	3.80	1.00	16.00
International grants	International development grants/GEF grant	101	0.39	0.90	0.00	5.15
National grants	National development grants/GEF grant	101	0.82	1.38	0.00	9.27
Public investments	Public investments (loans) / GEF grant	101	1.23	2.00	0.00	8.84
CDM						
Size of the economy	GDP in thousand billion 2007 USD	224	1.70	1.51	0.00	4.08
Size of project	Annual credits in the 1st crediting period	224	261.0	970.5	0.17	10017
Date of approval	Year of approval, deviation from 2005	224	2.76	1.08	0.00	6.00
Public investments	Public investments/abatement costs	224	2.46	6.94	-7.43	53.07

SD = Standard deviation; sources: economy size from World Bank (2011), all other GEF data are extracted from online project documents (GEF, 2011a), all other CDM data are extracted from Castro (2010) and complementary data from the project documents (UNFCCC, 2011f)

To analyze the potential for high multicollinearity, we have calculated Variance Inflation Factors (VIFs). VIFs for all our regression are below 2.5, indicating that we have low multicollinearity. As a rule of thumb, scholars have proposed that VIFs above 5-10 indicate serious multicollinearity. According to O'Brien (2007), even higher VIFs may not discount the results.

7.5.4 Regression results for projects supported by the Global Environment Facility

The regression results using data from project documents as dependent variable (see Table 24, left) show that the positive impact of private investment on cost-effectiveness is slightly lowered if we control for other covariates. This means that the positive influence of private investments on cost-effectiveness can be split into two parts. A larger part is due to more efficient financing of similar investment projects (which is what we have expected from theory), while a smaller part of the impact is due to selection of more efficient project types, which we did not expect from theory. Private investment alone can only explain a small part of the variation in cost-effectiveness (R^2=0.04). The fit of the model substantially improves if we include project type dummies and other covariates (R^2=0.50). Particularly the different RE types proved to be significant indicators for cost-effectiveness. Other potential determinants (development funding, approval year, project size, World Bank) do not have any significant effect.

If we look at the regressions on cost-effectiveness as reported by Terminal Evaluation (TE) documents (Table 24, right), private sector investments also remain a significant predictor after controlling for further variables. The coefficients on private sector investment are larger than in the project document case, and they have a larger decrease (from 0.3 to 0.2) when including additional covariates. Again, the decrease in the coefficient means that private investors do not only invest in more cost-effective among similar projects, they also select more cost-effective project types. This may be due to the variety of GEF projects, which also include projects with mainly capacity building and less investments in concrete technologies. Substantial investments in GEF projects may imply concrete technology applications and, therefore, more GHG emissions reductions. As with ex-ante project documents, several project types have an impact on cost-effectiveness, with RE projects (hydro, solar and mixed) showing a lower cost-effectiveness than "energy efficiency in households", the reference project type. Another significant predictor is the size of the economy.

Table 24: Regressing cost-effectiveness of GEF-supported projects

Dependent variable	Cost-effectiveness (logarithm)		Cost-effectiveness (logarithm)		Cost-effectiveness (logarithm)		Cost-effectiveness (logarithm)	
Estimation method	OLS		OLS		OLS		OLS	
Data	Project document		Project document		Evaluation data		Evaluation data	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Private investments	0.16	(0.06) **	0.14	(0.06) **	0.33	(0.14) **	0.20	(0.10) **
International grants			-0.02	(0.21)			0.68	(0.60)
National grants			0.09	(0.11)			0.23	(0.17)
World Bank			0.43	(0.48)			1.17	(0.79)
Size of the economy			0.00	(0.00)			0.00	(0.00) **
Size of project			-0.00	(0.03)			-0.09	(0.05) *
Date of approval			-0.02	(0.06)			0.01	(0.11)
Public investments			-0.09	(0.12)			0.23	(0.36)
EE industry			0.63	(0.75)			-3.35	(1.72) *
EE service			-1.00	(0.87)			-0.80	(1.73)
EE/RE combined			-1.02	(1.04)			-1.18	(1.32)
EE (Mix)			-1.39	(0.90)			-2.71	(1.38) *
HFC			0.83	(0.69)				
Methane			-0.91	(0.78)			-1.91	(0.98) *
Biomass power			-1.62	(1.03)			-1.18	(1.12)
Geothermal power			-0.98	(0.69)			-3.75	(1.12) ***
Hydro power			-2.39	(1.10) **			-3.86	(1.85) **
Renew. Energy (Mix)			-2.84	(0.70) ***			-3.76	(1.18) ***
Solar power			-2.80	(0.74) ***			-3.65	(0.91) ***
Wind power			-2.10	(0.91) **				
Transport			-0.79	(0.68)				
Constant	-1.77	(0.249) ***	-0.51	(0.90)	-2.38	(0.49) ***	-1.75	(1.35)
R^2	0.04		0.50		0.12		0.68	
N	89		89		40		40	
F-test (Prob >F)	0.01		.		0.02		.	

Significance levels: * = p-value of coefficient <0.1, ** = p-value <0.05, *** = p-value <0.01
SE = robust standard-errors
EE = Energy efficiency
Coefficients of project dummies express deviations from projects promoting energy efficiency in households (omitted dummy).

7.5.5 *Regression results for projects supported by the Clean Development Mechanism*

The CDM regression results for project documents (see Table 25, left) show that private investment intensity has again a significantly positive influence on cost-effectiveness. As the coefficient increases after controlling for other covariates, we can derive that the positive correlation of private investment intensity with cost-effectiveness is not due to the financing of more cost-effective project types but to the financing of more cost-effective among projects of the same type. This finding that private investments finance the more cost-effective among similar projects is what we expected from hypothesis 2. The coefficient on private investment is 0.11, which means that cost-effectiveness increases by approximately 10% per additional unit of private investment intensity. However, investment intensities alone can only explain a small part of the variation in the cost-effectiveness of projects (R^2=0.06). Model fit substantially improves (R^2=0.73) if we include project type dummies and other covariates. Particularly the various non-CO_2 project types (N_2O, SF_6, methane avoiding projects) explain a substantial part of variation in cost-effectiveness. As expected, projects have become less cost-effective over time.

When looking at data from evaluated CDM projects (see Table 25, right) we have similar results than for data from project documents, although most coefficients are less significant and some project type dummies were omitted due to the smaller sample size. Private investment intensity has again a highly significant positive influence on cost-effectiveness, and given that the coefficient is higher when controlling for project types, we can derive that private investors do not select the most cost-effective project types but the more cost-effective among similar projects.

Table 25: Regressing cost-effectiveness of CDM-supported projects

Dependent variable	Cost-effectiveness (logarithm)			Cost-effectiveness (logarithm)			Cost-effectiveness (logarithm)			Cost-effectiveness (logarithm)		
Estimation method	OLS			OLS			OLS			OLS		
Data	Project document			Project document			Evaluation data			Evaluation data		
	Coeff.	SE		Coeff.	SE		Coeff.	SE		Coeff.	SE	
Private investments	0.09	(0.03)	***	0.11	(0.02)	***	0.11	(0.08)		0.20	(0.08)	**
Size of the economy				0.00	(0.00)	***				0.00	(0.00)	
Size of project				0.00	(0.00)					0.00	(0.00)	
Date of approval				-0.21	(0.07)	***				-0.34	(0.16)	**
Public investments				0.06	(0.01)	***				0.04	(0.02)	**
Cement				0.30	(0.35)					-0.20	(0.79)	
Coal-Bed methane				1.30	(0.29)	***				-0.33	(0.52)	
EE households				1.03	(0.36)	***				1.32	(0.64)	**
EE industry				-0.34	(0.68)					0.42	(0.44)	
EE own generation				0.50	(0.21)	**				-0.11	(0.87)	
EE service				-0.68	(0.29)	**				n/a		
EE supply side				0.04	(0.25)					n/a		
Fossil fuel switch				-0.67	(0.00)	***				-0.16	(0.88)	
Fugitive emissions				0.86	(0.62)					n/a		
Geothermal power				0.14	(0.30)					0.69	(0.78)	
Hydro power				-0.49	(0.26)	*				0.69	(0.68)	
Landfill gas				1.37	(0.23)	***				1.92	(0.67)	***
Methane avoidance				1.11	(0.25)	***				1.21	(0.63)	*
N_2O destruction				2.82	(0.61)	***				3.58	(0.68)	***
PFC/SF_6 avoidance				2.62	(0.54)	***				3.10	(0.63)	***
Reforestation				1.53	(0.32)	***				n/a		
Solar power				-3.03	(0.55)	***				-1.64	(1.04)	
Wind power				-1.16	(0.21)	***				-0.46	(0.49)	
Constant	-1.83	(0.00)	***	-2.36	(0.31)	***	-2.35	(0.26)	***	-2.82	(0.84)	***
R^2	0.06			0.73			0.01			0.67		
N	218			218			68			68		
F-test (Prob >F)	0.00			-			0.06			-		

Significance levels: * = p-value of coefficient <0.1, ** = p-value <0.05, *** = p-value <0.01
SE = robust standard-errors
EE = Energy efficiency
Coefficients of project dummies express deviations from project promoting biomass (omitted dummy).

Summing up, the CDM results confirm the GEF results that private sector investment may help a non-informed policymaker in choosing GHG reduction projects, but there is clearly a better indicator for cost-effectiveness (the project type), so private investment should rather be a secondary funding allocation criterion after the most cost-effective project types have been pre-selected. The use of private investment as secondary criterion is possible as the coefficient on private investment remains positive and significant after controlling for other determinants, in both the GEF and the CDM case. This result is true for both data from project documents and evaluations.

7.6 Discussion: Reasons to be cautious about private finance as project selection criteria

Generally, the positive correlation between private finance and cost-effectiveness as well as the significant positive impact of private investments on cost-effectiveness in regression models imply that projects involving private investment are more cost-effective than projects without mobilizing private investments, so private finance could be an interesting project selection criteria for a public institution that is non-informed about cost-effectiveness of projects.

However, there are several reasons to be cautious about using private investment intensity as project selection criterion. Such reasons are both resulting from our empirical analysis and reasons beyond this analysis.

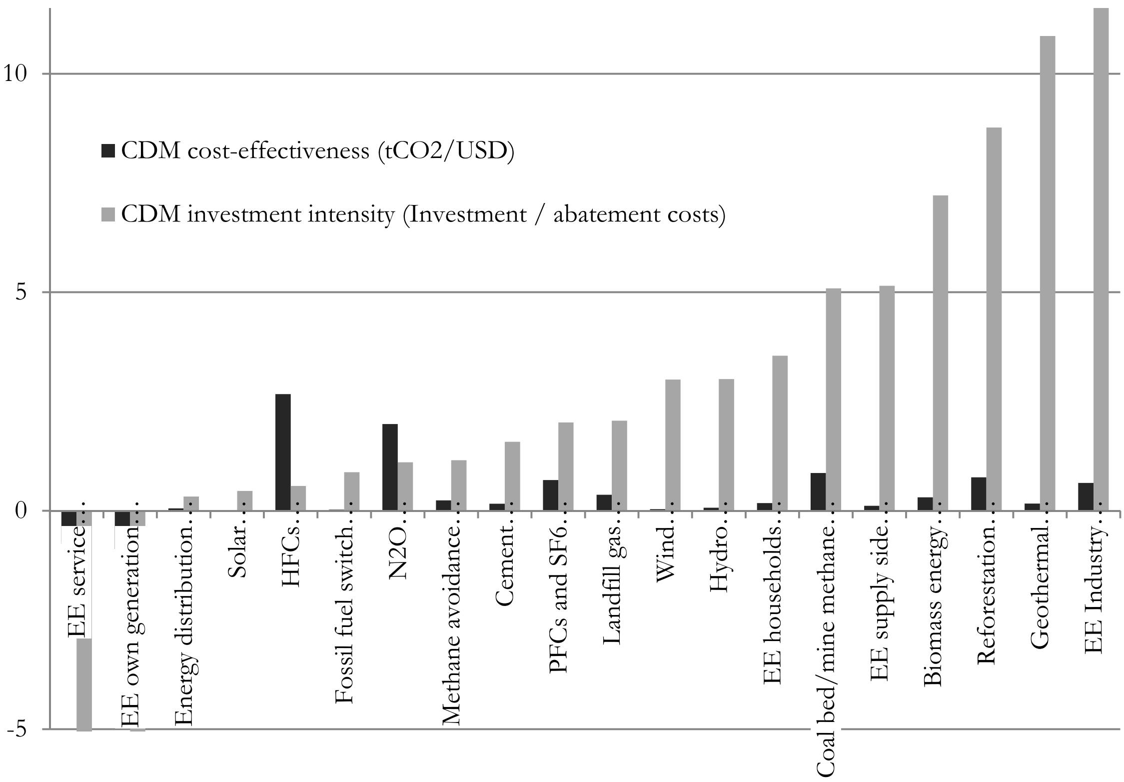
7.6.1 Reasons derived from the empirical analysis: low correlation and public investments

One reason we can derive from the empirical analysis is that the correlation between cost-effectiveness and private investment is quite low (coefficient around 0.2), so the knowledge of the public institution on cost-effectiveness of projects has to be limited in order that private investment intensity as primary project selection criteria can help him improving cost-effectiveness compared to allocation according to his own knowledge on cost-effectiveness.

The low correlation between private finance and cost-effectiveness is partly related to the fact that most of the very cost-effective non-CO_2 projects (particularly N_2O, methane avoidance but also HFC, which was not analyzed in our case) have low investment intensity close to one (see Figure 21). The private investment intensity is equal to one if climate finance is the only source of revenue. In such cases, the abatement costs are equal to the investment costs, and the investment intensity is one, as it is defined as investment costs per abatement costs. Therefore, a public institution has to assure that it does not exclude these project types when using private investment intensity as criterion for allocation of funding. Once the most cost-effective project types are pre-selected by the public institution, private finance may be useful as secondary criterion to select among several projects of the same type given that the regressions have shown that the influence of private investment intensity on cost-effectiveness remains quite stable when controlling for the project type. Our detailed analysis also shows that the correlation between investment intensities and cost-effectiveness substantially increases if we look at RE, energy efficiency and non-CO_2 projects separately.

Another reason to remain cautious that we can derive from the empirical analysis is the fact that in several countries (e.g. China) public investment plays a major role. In our CDM sample, we have found that in around 40% of projects, the public sector has at least partial ownership. While our regression analysis has shown that publicly-owned projects tend to be less cost-effective, some of the most cost-effective projects in the sample are still publicly owned. Therefore, public institutions should not blindly focus on private investment when supporting projects but also consider public investors in countries with largely government-owned companies, such as in China. Still, as we find in most cases higher coefficients of public than private investment intensities, private investors may lead to more cost-effective results when a real choice between public and private investors is occurring[94].

Figure 21: Cost-effectiveness and total (public and private) investment intensity of different CDM project types



Source: Stadelmann et al. (2011c)

7.6.2 *Reasons beyond the analysis: support for BAU projects*

A further reason why policy-makers have to be cautious when using private investment intensity as project selection criteria is that some of the projects we analyzed may be BAU projects, which is not revealed by the GEF/CDM data we have used, as this data assumes that all projects are mobilized by GEF/CDM. In other words, our operationalization of cost-effectiveness in supporting climate change mitigation projects is not perfect, given missing data on whether some projects are BAU.

Support for BAU projects is particularly relevant in the private finance context as high private investment intensities for energy projects may be an indication that these projects are not additional to the BAU case. This can be illustrated with the case of electricity from renewable energies, assuming that all technologies receive the same price per generated unit of electricity[95]. A very expensive technology

[94] However, within our analysis we could not control for all influence factors that may affect relative cost-effectiveness of public and private investors. For instant, public investors undertake more risky interventions, so their projects are less cost-effective by purpose. A counterargument would be that some private actors take over substantial risks in order to secure markets.

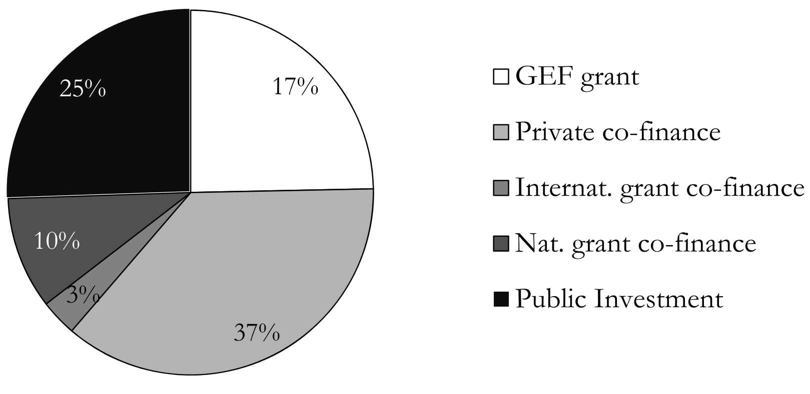
[95] This assumption only holds in a liberalized and competitive electricity market where tariffs for electricity fed in to the grid are the same for all technologies. In many countries, this assumption does not hold as different renewable energies receive different feed-in tariffs covering the production costs of each technology. However, in such cases, the idea of mobilizing investment and reducing GHG with climate finance becomes less relevant, as investments in RE will be undertaken anyway.

like solar PV will need a substantial amount of climate finance compared to the electricity revenues, so that the investment intensity will be very low. Compared to this, a technology almost competitive on the market, like wind or hydro, will only need a very small amount of climate finance compared to the electricity revenues, so the investment intensity will be high. If the technology is very close to competitiveness, then abatement costs tend to zero and the investment intensity goes to infinity.

Given that countries and project developers have an interest to receive climate finance, they may tend to report not negative but very small costs for already profitable technologies. Such projects are very challenging for policymakers: projects close to zero abatement costs may either be the most cost-effective options for financial support, if costs are indeed very low, or they may be the least cost-effective options for financial support, if costs are negative and the investments would have taken place anyway. This challenge has been discussed in the CDM literature where several studies (Michaelowa and Purohit, 2007; Schneider, 2007; Haya, 2009) have concluded that it is very difficult for CDM verifiers to detect which projects are profitable (and therefore part of BAU) and which ones not. In conclusion, very high investment intensities for energy projects may either mean that supporting them is very cost-effective but it may also signal that the project is already competitive, so support is very cost-ineffective as public climate finance will not generate additional GHG emissions reductions.

In case of the GEF, it is particularly questionable whether all of the GHG emissions reductions and private investments are mobilized by public climate finance. Figure 22 shows that 43% of GEF project finance comes from international and national grants or loans, which can also be expected to have a "mobilization effect". An interviewee from a GEF implementing agency (see Annex 10.1) even said that according to his impression, it is rather the public co-finance (grants and loans) mobilizing the GEF funding, and not the GEF funding mobilizing the co-finance. While this is certainly an overstatement, given that the amount of GEF funding per country is given, it supports the idea that not all private investment, and even less the other co-funding, is mobilized by GEF grants. So GEF statements like "we have provided more than US$8.6 billion [...], leveraging more than US$36 billion in co-financing" (GEF, 2009b: 1) are certainly over-estimating the real finance mobilization by GEF. For a review on GEF and other public institutions misleading definitions of "leveraged" co-finance, see Brown et al. (2011).

Figure 22: Financing of GEF projects (sample of 101 out of 190 projects with disbursements until 2009)



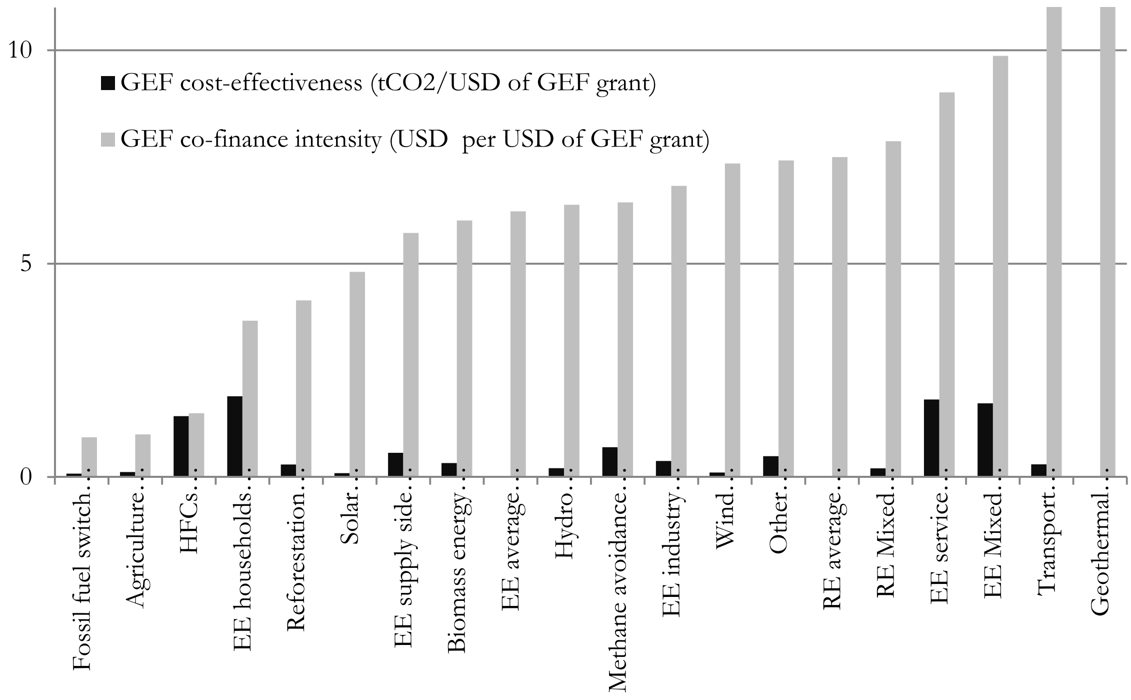
Source: own analysis derived from GEF project documents (GEF, 2011a)

The question whether projects are BAU or not also applies to projects where the abatement costs of a low-carbon technology are negative as the revenues of this technology are larger than the investment and operation costs, which is the case for many energy efficiency projects. The implementation of these projects is hindered by high transaction costs and market failures such as asymmetric information (Jaffe and Stavins, 1994; Kesicki and Ekins, 2012). In case of GEF, most of these transaction costs are included in the cost-assessment, so costs are positive and, therefore, both cost-effectiveness and private investment intensities are positive (see Figure 23). Indeed, GEF only supports energy efficiency technologies if it can be shown that transaction costs (e.g. capacity building) are to be covered. However, as actual abatement costs for the GEF-promoted energy efficiency technologies are often negative, it is possible that national government would promote these projects anyway (or the private sector undertakes them anyway), so projects are BAU and GEF support is not needed. To better understand whether this is the case or not, a closer look at specific projects would be warranted.

In the CDM case, most transaction costs are not included in the assessment of negative abatement cost projects so projects have negative costs and, according to our definitions, we receive the strange result that cost-effectiveness and private investment intensities can be negative for some energy efficiency projects (see Figure 21). How to interpret such negative values, does it mean that projects are cost-effective or not? We may face two situations: In the first situation, the projects are still profitable after transaction costs are included, so projects are BAU[96], and CDM support is not needed. In this case, negative cost projects *on their own* are very cost-effective, as no costs occur, but *their support* via CDM would not be cost-effective, as CDM generates no effect but at least some administrative costs occur. In the second situation, overall costs including transaction costs are positive, so climate finance is needed. In this case, cost-effectiveness of support by the CDM can be very high if costs including transaction costs are low. But how to correctly specify these transaction costs? In the CDM, project developers operationalize such transaction costs by claiming technological or financial barriers. Yet, these barriers can hardly be assessed in an objective way (Schneider, 2009b). Similar to the case of competitive hydro power projects, small differences in costs can have a substantial impact on the assessment whether such energy efficiency measures are very cost-effective on their own (as costs are negative), and should, therefore, not be supported at all because they are profitable, or whether supporting them is very cost-effective due to low costs. Therefore, negative private investment intensity may both mean very high or very low cost-effectiveness of climate finance support.

[96] As mentioned in the introduction to this thesis, negative cost projects are not necessarily BAU, as they can face high transaction costs. However, once transaction costs are included in the assessment, negative cost projects should be BAU (if one assumes that no market failure like asymmetric information occurs).

Figure 23: Cost-effectiveness and co-finance intensity of different GEF project types



Source: Stadelmann et al. (2011c)

7.7 Discussion: Explaining public calls for private finance mobilization

Why do public agencies continue calling for more mobilization of private sector funding? Our results show that cost-effectiveness of climate policy cannot really be the reason if public institutions are well informed. Therefore, we analyze other explanations why public institutions are calling for private finance: alternative public policy goals, own interests of bureaucrats and politicians and misleading perceptions of the public sector on cost-effectiveness.

7.7.1 *Alternative public policy goals*

One main reason why policy makers may call for private finance mobilization is that they have other public policy goals (e.g. private sector engagement, capital for long-term projects and environmental effectiveness) than reducing GHG emissions cost-effectively. We will discuss whether these potential alternative goals are really alternative policy goals, which can justify a focus on mobilizing private finance, or whether they are rather intermediate targets to achieve cost-effectiveness in the end. In case of real alternative policy goals, it will be discussed if they really imply a focus on mobilizing private finance.

Private sector engagement: the GEF has been criticized that it has not been successful in engaging the private sector sufficiently (Streck, 2001; GEFEO, 2002, 2005)[97]. Is "engaging the private sector" an

[97] One may question this critique given our analysis that roughly 40% of funding in GEF projects is coming from the private sector and the assessment of Clémençon (2006) that GEF private sector co-financing is way higher than the voluntary partnerships for sustainable development emerging from the Johannesburg summit in 2002.

alternative or an intermediate policy goal? In our view, it is always an intermediate policy goal, which does not depend on the reasoning given for engaging the private sector. If it is needed to improve short-term cost-effectiveness in implementation, as supported by our analysis and a literature review by Mueller (2003), then it is clearly an intermediate policy goal. If the private sector has to be engaged, to build capacity and create interests of the private sector for long-term mitigation, similar to long-lived tradable allowances that create private sector interests in climate policy (McKibbin and Wilcoxen, 2007), then it should also serve cost-effectiveness but only in the long term.

Capital for technologies with very long-term lifetimes: For achieving ambitious emission reduction targets, low-carbon technologies with very long lifetimes and thus large investment volumes (e.g. buildings, power plants) have to be implemented as early as possible (Lecocq et al., 1998; Michaelowa and Rolfe, 2001; Jaccard and Rivers, 2007; Vogt-Schilb and Hallegatte, 2011). As we understand the argument, capital for long-term investment is not a goal in itself but a mean to achieve cost-effectiveness in the long-term: if only investments with short technology lifetimes are implemented in the short run, then climate policy may become very costly in the long run, as not yet amortized technologies may have to be replaced (Vogt-Schilb and Hallegatte, 2011). This problem can partly be handled if cost and benefits are measured along longer periods, as conducted in our assessment of GEF projects. However, even our long-term cost-benefit assessment may not lead to the highest long-term cost-effectiveness if long lifetime technologies (e.g. building energy efficiency) required to achieve the 2-degrees target remain very cost-ineffective, even under a long-term cost-effectiveness assessment. This would imply that implementation of long lifetime projects may be postponed leading to high economic costs when non-amortized investments (e.g. energy-inefficient buildings) have to be replaced later on. This supports the potential usefulness of private investment intensity as intermediate policy goal in a high ambition policy scenario[98], while it is not an argument for considering it as alternative policy goal. The long-term investment argument makes clear that policy makers will have to reflect long-term goals and the risk of having to replace non-amortized technologies when analyzing cost-effectiveness of their decisions. Such an inter-temporal analysis of cost-effectiveness goes beyond the scope of this paper.

Environmental effectiveness: Policy makers may not be primarily interested in cost-effectiveness of climate policy but in overall effectiveness in reducing GHG emissions. This is clearly another policy goal than cost-effectiveness but does it justify a focus on private finance mobilization?

First of all, the same logic as for the case of cost-effectiveness as policy goal can be applied: if a public institution is really aiming at environmental effectiveness it may simply choose the projects with highest effectiveness per unit of climate finance. As long as the public institution is well-informed and able to select the projects that mitigate most GHG per unit of public finance, a new focus on projects mobilizing private finance cannot help to improve effectiveness. Only in case that the public institution is not informed about effectiveness of mitigations options, focusing on private finance mobilization can help a public institution to improve effectiveness of climate finance.

The analysis is different in the special case that a public institution aiming at environmental effectiveness only has information about cost-effectiveness in reducing GHG but not effectiveness per unit of climate finance. For this situation we can use our previous analysis (in Table 19) on a public institution that, by default, selects the most cost-effective projects: if mobilized private finance does not cover any abatement costs, effectiveness in mitigating GHG emissions should be maximized with the same projects that maximize cost-effectiveness, so a focus on projects that mobilize most private finance will tend to lower effectiveness compared to the selection of the most cost-effective projects. In this case,

[98] However, not all of these expensive but long-term low-carbon projects are private investment intensive, e.g. solar power will probably be needed under high ambition mitigation scenarios but private sector intensity is currently low.

effectiveness is not an alternative public policy goal and does not justify the switch from cost-effectiveness to mobilizing private finance as criteria for allocation of climate finance. However, the analysis is different if mobilized private finance consists of private abatement spending. In this case, mobilizing private finance increases the overall amount of abatement spending (if public climate finance is fixed), which is actually a *net* increase, as we have to deduct the climate finance spent for mobilization, which cannot be used anymore for reducing GHG emissions. This net increase in abatement spending *can* increase GHG emissions reductions (see Table 18) but only if the additional GHG emissions reductions due the net increase in abatement spending can compensate for GHG losses emerging from the shift to less cost-effective projects.

In conclusion, environmental effectiveness as alternative policy goal *can* justify a focus on mobilizing private finance (rather than a focus on the most cost-effective projects) but only if a) the public institution has only information on cost-effectiveness but not effectiveness per unit of public finance, b) a net increase of abatement spending occurs when focusing on private finance mobilization, and c) additional GHG mitigation mobilized by the net increase in abatement spending compensate for a shift to less cost-effective projects. However, it is highly unlikely that these conditions are all given, particularly a net increase in abatement spending due to private finance mobilization seems very unlikely[99].

Summing up, two potential alternative policy goals – engaging the private sector and capital for long-term projects – are in fact intermediary policy goals to achieve cost-effectiveness in the end, so they rather call for a closer cost-effectiveness assessment and not for mobilizing private finance on its own. Only environmental effectiveness can be seen as a goal on its own that may justify the selection of projects with most private finance mobilization (instead of the most cost-effective projects) if some conditions are given: the public institution has to be non-informed about effectiveness per unit of public finance (otherwise it could simply maximize effectiveness by choosing the right projects), the mobilized private finance has to lead to a net increase in abatement spending, which is quite unlikely, and the additional GHG emissions reductions have to compensate for losses due to the shift to less cost-effective projects.

7.7.2 *Self-interests of public institutions and politicians*

The explanations discussed before assume that public institutions act in the interest of the public. However, officials may also or even mainly pursue their own interests (Mueller, 2003). Why could calls for private finance mobilization be in the self-interest of politicians and government officials? For them, the easiest way to meet a finance target including public and private sources is to ensure that the private share is maximized. By mobilizing private finance, the goal can be achieved without being dependent on public budgets that are under pressure. Furthermore, public institutions can also take advantage of the widely shared view (Mueller, 2003) that the private sector is in most cases more cost-effective, so voters

[99] Such a net increase in abatement spending only occurs if the private sector pays for some investment or operation costs without being fully compensated by some non-climate or public climate revenues. Such a mobilizing of private abatement spending by climate finance seems to be unlikely as can be illustrated for all reasons of private sector cost coverage: philanthropy and strategic investments, financial incentives and regulations. In case of philanthropy and strategic investments, the private coverage of abatement costs is voluntary, so not due to public climate finance; if costs of philanthropic or strategic investments are covered by climate finance, no net increase in abatement spending occurs. In case of financial incentives via climate finance subsidies, the private sector does not spend on abatement on its own, as the costs are covered by climate finance. In case of abatement spending due to governmental regulations (e.g. standards) or government-induced financial incentives (e.g. taxes, ETS) in the South, the abatement spending is not likely to be higher than the climate finance spent for mobilizing these regulations and financial incentives, as the respective country would have higher costs than its compensation.

and tax payers may perceive high figures for mobilized private finance as indication for improved cost-effectiveness even if it is not necessarily true.

7.7.3 Misleading perceptions of the public sector on cost-effectiveness

Finally, it may also be the case that some public sector officials see the maximization of private finance mobilization as cost-effective because of misleading perceptions: either they make the foregone judgment that private finance must always improve cost-effectiveness because the private sector is efficient, or they only consider public sector costs in their cost-effectiveness assessment and neglect private sector costs.

7.8 Conclusions

From a theoretical point of view, the mobilization of private finance as new policy goal may decrease cost-effectiveness and effectiveness of climate policy. The reason is that introducing a second goal (private finance) in climate change mitigation policy will lead to trade-offs with the primary goal (GHG mitigation). Empirical data from the GEF and CDM as two international climate finance mechanisms confirms that selecting programs according to "mobilized private finance" will substantially decrease cost-effectiveness of climate finance compared to a situation where well-informed public institutions already select the most cost-effective GHG reducing projects.

Only in a situation where public institutions are missing information on relative cost-effectiveness of projects, selecting projects according to the mobilization of private finance may be beneficial as private finance is positively correlated with cost-effectiveness and the positive relationship is persistent when controlling for other determinants. Still, our empirical analysis has shown that the project type is a much better indicator for cost-effectiveness, so private investment should rather be used as secondary criteria for project selection after considering the project type. Furthermore, notwithstanding the significant correlation, private finance may not be a robust indicator for cost-effectiveness of climate finance because high private investment intensity can be an indication that projects are actually BAU, and do not need climate finance support.

Why are policy makers calling for mobilizing as much private finance as possible even if it is possible that it decreases cost-effectiveness? The calls can be explained by three different reasons: first, policy makers may pursue different public policy goals such as improving environmental effectiveness. Improvements in environmental effectiveness via private finance mobilization are, however, highly unlikely as the public institution would have to be non-informed about effectiveness of projects, and the mobilized private finance would have to cover costs of GHG emissions reductions (without compensation by any revenues), which is unlikely to happen if the private sector is profit-oriented. Second, mobilizing private finance may be in the self-interest of public officials; private finance helps policy makers to achieve international financing goals and reduce the need for raising taxes. Furthermore, showing high private finance numbers may be an attractive way for policy makers to claim high performance as the public does not understand that cost-effectiveness may be lowered. Third, policy makers may simply have the foregone conclusion that mobilization of private finance will always improve cost-effectiveness. Among the three potential explanations, self-interest of public officials seems to be the most reasonable explanation but interviews would have to be conducted to reveal this.

In a broader sense, the main lesson of this paper is that means and ends of climate policy are not to be confused: while mobilizing private sector investment may be an important mean of climate policy, given the substantial need for investments in low-carbon technologies in the next decades (Olbrisch et al., 2011), it is not the final goal. The private sector has a key role in financing and implementation of climate policy (e.g. within the carbon market or in public-private partnerships) but policymakers should be cautious about seeing private finance as goal on its own.

This study leaves research gaps in at least two areas. First, the empirical part could be extended to further funding channels and instruments. Given data constraints we focused on certain climate finance instruments, e.g. performance-based payments (CDM), capacity building and financing instruments (GEF), while we omitted certain project types hardly or not promoted by CDM and GEF (reduced deforestation, nuclear power and agricultural projects) and further instruments where a more substantial link between private finance mobilization and cost-effectiveness is possible (e.g. public guarantees). Second, it remains unclear whether alternative policy goals, own interests of policy makers or misjudgment on cost-effectiveness is the best explanation for policy maker's calls for mobilizing private finance. Expert interviews would help to bring more light into this question.

The research results have important implications for climate policy. In climate change policy, it seems that the goal of mobilizing USD 100 billion from public and private sources bears the risk that public institutions have incentives to prioritize programs with the highest intensity of private sector finance. Unfortunately, these programs will probably not be the most cost-effective ones. Therefore, it would be beneficial to replace the USD 100 billion goal with a lower public finance goal or, even better, with a GHG reduction and adaptation target. If this is not possible, public institutions should at least refrain from selecting programs according to private sector mobilization as long as they have better indicators or knowledge about cost-effectiveness.

These conclusions can be transferred to other policy areas, e.g. development assistance. Whenever a primary policy goal like public health is supplemented with the additional goal of mobilization private finance, then achievement of the primary goal will probably decrease, if public institutions are well aware of cost-effectiveness of options.

8 Conclusions

This final chapter will discuss conclusions on the effectiveness of international climate finance in supporting low-carbon development. First, the research questions are answered based on the previous chapters, then the internal and external validity of the results is discussed, and finally some implications for policy making and further research are lined out.

8.1 Answers to research questions and validity

In this section, we will answer the four research question on the effectiveness of international climate finance as set out in chapter 3 (literature and research gaps), relying on the analysis conducted in chapters 4 to 7. Furthermore, the validity of the results are discussed, both the internal validity (within the studied cases) and the external one (generalizability beyond the studied cases)[100]. Answers and validity are discussed for each of the four research questions separately.

8.1.1 Effective definitions of "New and additional"

Chapter four addressed the first question, which focused on the provision of climate finance: *How would the term "new and additional" have to be defined to enable an actual increase of climate finance without redirection of development aid?* For answering this question, the chapter discussed eight different options to define "new and additional" climate finance.

From a climate finance effectiveness point of view, the option "above existing climate finance" is most effective. The option "above existing climate finance" implies that new and additional climate finance must exceed past climate finance levels, so more funding for climate change mitigation should be available under this definition. Furthermore, the definition "above existing development assistance" may also lead to comparative high climate funding and more environmental effectiveness, as contributors are free in how to allocate a planned increase in funding for developing countries, so they can allocate all to climate change. Other baseline definitions, such as "above 0.7% of ODA", "no ODA", "only new UN channels", "only new source", or "above development assistance an and climate finance projections" are considered to restrict the provision of climate finance, and may, therefore, reduce the effectiveness in reducing GHG emissions.

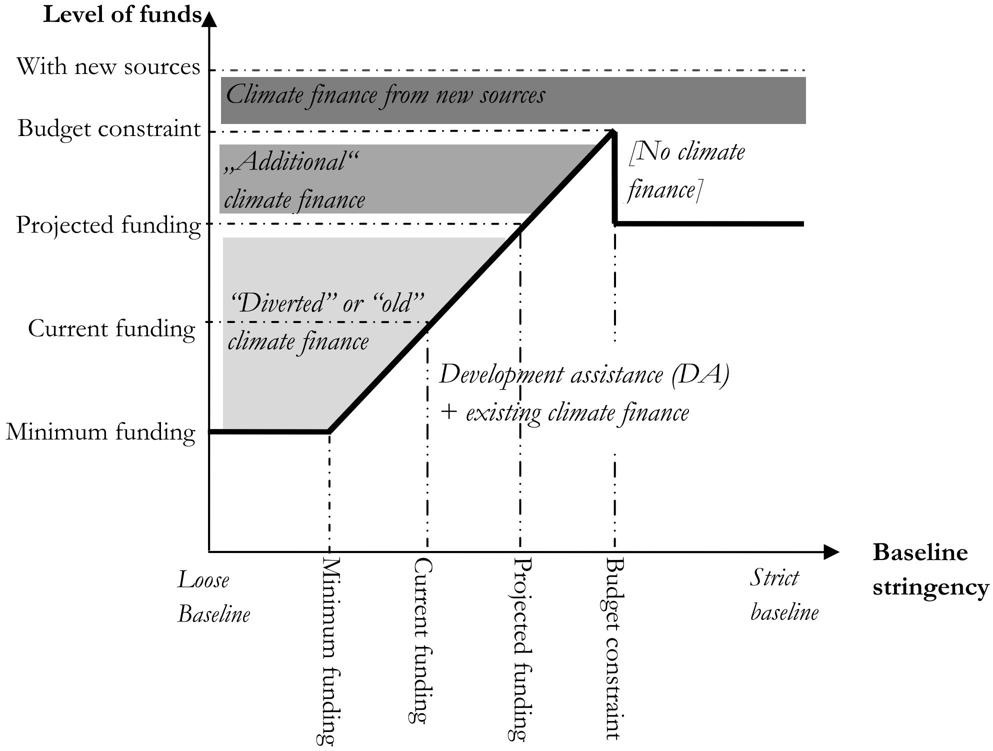
However, options most beneficial for provision of climate finance and environmental effectiveness may lead to substantial diversion of development assistance to climate finance, and are, therefore, not acceptable to most developing countries[101]. Figure 24 (slightly adapted from figure 12 in chapter 4) illustrates the resulting dilemma in the definition of "new and additional" climate finance. If a high level of development assistance (DA) and climate finance is set as baseline, no development assistance should be diverted and no "old" climate finance pledged as "new" but then the possibility to provide new climate finance would be restricted, if we assume a budget constraint. If, in contrast, a low level of funding is set as baseline, substantial climate finance should flow but funding will be diverted from

[100] See Campbell et al. (1966) for the fundamental distinction between internal and external validity.

[101] In addition the option "above existing climate finance" may not be institutionally feasible as data of existing or past climate finance is not available: while ODA donors report to the OECD how much of their ODA has climate change as significant or principal objective, the assessment is deficient in practice (Roberts et al., 2010a; Michaelowa and Michaelowa, 2011a), and no definition of climate finance has yet been agreed on internationally (Buchner et al., 2011a; Haites, 2011).

development assistance or will also consist of "old", re-counted climate finance, so it will hardly be acceptable for developing countries.

Figure 24: Impact of climate finance baseline in case of budget constraint (with potential new sources)



According to our analysis, two baseline options may minimize the trade-offs and be politically and institutionally feasible: "above pre-defined projection of DA and climate finance" and "new sources". The first one, "above pre-defined projection of DA and climate finance" would avoid diversion of development assistance and still imply that climate finance will flow, assuming that the DA and climate finance projection does not reach the budget constraint. The second compromise, "new sources", essentially increases the budget constraint by mobilizing new financial sources (e.g. via CO_2 taxes or auctioning of allowances) so diversion of DA becomes unlikely, while the amount of climate finance increases. Trade-offs may even be further minimized if the two baselines are combined: "from new sources or above pre-defined BAU level of DA and climate finance". In this case, neither DA should be diverted nor "old" climate finance relabeled as "new" and all potential sources (general budget and new sources) may be tapped for climate finance, thereby improving "environmental effectiveness".

Are these results for the term "new and additional" climate finance valid, both internally (situation at the moment, which we analyzed) and externally (situations in the past and the future)? Internally, the results may be challenged on the premise that there is no absolute ceiling for the budget, so actually an ambitious definition of the baseline may lead governments to provide more funding for developing countries. A counter-argument is that industrialized countries have never been willing to agree on a definition for "new and additional" and that they have never come close to the 0.7% of GNI provided as

ODA, which both indicates that there are some limits to funding provision, even when they are flexible over time.

Another challenge for the internal validity of the results may be the thesis that the term "new and additional" funding may matter even without a clear definition. We can derive this thesis from interviews conducted with representatives from industrialized governments (see 10.1). However, while these interviewees indicated that the term "new and additional" induced them to provide additional climate funding, their wording also suggested that actually some DA funding was diverted, so the dilemma between climate and development funding still exists.

Finally, it is very difficult to say how externally valid (so generalizable beyond the present) our results are. When some assumptions change, the judgment of the baseline options may also change, e.g. if ODA will not rise but decrease, then "above current DA and climate finance" would be less environmentally effective as more resources than planned would have to be spent for DA to meet the baseline. If more countries move beyond the 0.7% of GNI provided to ODA, the "0.7% GNI" baseline will become politically more acceptable, but less effective. As well, the world of climate finance contributor may substantially change, as all countries – including non-ODA providers – could become contributors of climate finance, as suggested by the Mexican proposal for a World Climate Change Fund (Gomez Robledo, 2008). In such a case, the term "new and additional" may have to be restricted to industrialized countries or to be related to "climate finance" for non-ODA contributors.

8.1.2 Effectiveness in supporting RE diffusion

Chapter 5 analyzed the second question, which was based on the challenge that the CDM may not reach the theoretical effectiveness due to the problem that some BAU projects are supported: *How effective has the CDM been in reducing GHG emissions via renewable energy diffusion, and how effective has public finance been in comparison?* We analyzed this question by estimating the determinants of the diffusion of renewable electricity production in more than 120 developing countries, using both fixed effects and random effects, as well as Generalized Methods of Moments models.

According to our models the CDM has no significant effect on renewable electricity production apart from the case of biomass (and potentially geothermal and hydro) power. Other determinants, such as dependence on foreign oil, national policies and RE potential were decisive for diffusion of renewable energies in the last 20 years. Only in case of biomass power, CDM has clearly a significant impact, while there was clearly no impact in case of solar and wind power. In case of geothermal power, CDM has a significant impact according to few specifications but the mean effect is lower than the official CDM figures (significantly lower if 10 year persistence of one-year effect is assumed, but not significantly lower if 20 years is assumed). In case of hydro, models also estimate a significant effect according to very few specifications but hydro power diffusion was generally difficult to model. The CDM effectiveness in case of biomass electricity can be explained by the fact that – at past CDM credit prices – the CDM support was available to cover the abatement costs of many biomass technologies, particularly biogas and waste water treatment plants (Schneider et al., 2010), while in case of other technologies, CDM support was either not substantial enough to cover abatement costs (wind and solar), so public policies were needed to make projects feasible, or projects may have been profitable anyway, e.g. in case of some hydro power projects (Schneider, 2007; Haya, 2009). This implies that CDM governing institutions – in the case of solar and wind, but also potentially geothermal power– either intentionally approved BAU projects or approved them as they were not aware that these projects are BAU due to asymmetric information. Intentional approval of BAU projects will at least partly take place, because of two reasons: First, some

CDM EB decisions have been connected to interests of host countries and the World Bank (Flues et al., 2010). Second, the EB rule that reductions due to climate-friendly policies are also credited will by definition lead to CDM approval of BAU projects.

The same models find that GEF has a significant impact on geothermal and wind power, although a lower one than officially reported. In case of biomass, hydro and solar, the models suggest no significant impact, so the GEF may have overestimated its effectiveness for all technologies (although in case of hydro, the over-estimation by official estimates is not significant). This overestimation seems reasonable because of several reasons. First, implementing agencies and GEF may feel inclined to seem effective in reducing GHG emissions, while GEF contributors and their tax-payers can hardly review claimed effectiveness because of asymmetric information. The idea that GHG figures may be important for GEF actors is supported by the fact that they are prominently placed in GEF brochures (GEF, 2009b, 2011c). Second, expert interviews revealed that the selection of GEF supported programs is not mainly based on cost-effectiveness but is a result of bargaining among national ministries, strategic considerations within implementing agencies and also the GEF itself. These "political" or administrative costs along the complex GEF supply chain (a result of the early set-up of GEF, see Fairman, 1996) make it very unlikely that the GEF can reduce GHG emissions for the claimed 4 USD per tonne of CO_2 (or around 0.2 US-cents per kWh of renewable power), which would be substantially below the incremental technology costs of most renewable energies (Edenhofer et al., 2011). Third, estimating the GHG impact of GEF's capacity building activities is technically very difficult or even impossible (Mee et al., 2008), so GEF agencies may also unintentionally overestimate reductions. Finally, several studies have found that GEF's GHG estimation methods are not very elaborated (Eberhard et al., 2004; Mee et al., 2008; Stadelmann, 2009).

Are these results internally and externally valid? Internal validity will mainly depend on the quality of the model: while the GMM model estimates with robust standard errors reflect potential heteroskedasticity, autocorrelation and most sources of endogeneity, it cannot be ruled out that some determinants have been omitted or not been adequately measured, which would lead to biased results. The selected independent variables are based on a literature review, so the quality of the model will depend on how well the literature has grasped the most important determinants on RE diffusion. Furthermore, some of the data is based on reporting by countries (e.g. the data on RE production), and it was not possible to review the quality, apart from the fact that the data generally seemed to be reasonable, based on the cross-country knowledge of the researcher. Therefore, it cannot be ruled out that the results are not fully valid. However, validity of the results is backed by existent case study research on CDM RE projects, which have shown that many RE projects would have also happened without CDM support (Michaelowa and Purohit, 2007; Schneider, 2007; Haya, 2009) and that abatement costs for solar and wind power are much higher than CDM market prices, while hydro power projects can already be profitable (Schneider et al., 2010).

External validity of the results is either not necessary or limited: generalizability to other countries is not necessary, as we have covered all countries that received climate finance for renewable energies. In contrast, generalizability to other time periods is only possible to a limited extent: the effectiveness of the CDM in promoting renewable energies is dependent on the carbon price and RE technology costs, which both will change: if the carbon price rises (currently not the case) and/or technology costs fall (as projected, see Nemet, 2006; Edenhofer et al., 2011), wind and solar power may once effectively be financed by CDM. However, once these technologies become profitable, CDM would become very ineffective in promoting them, unless the CDM regulators exclude them. The optimal inclusion or exclusion of specific RE technologies from the CDM will, however, be very difficult to determine, as it may not be very clear if technologies are profitable, see the case of hydro power. In case of GEF, validity relies on the question whether its capacity building tools will – in the future – still be effective for already well-known technologies, such as onshore wind. For staying effective in case of wind and geothermal, and becoming effective in case of biomass, hydro and solar, GEF programs may have to focus on more advanced technologies that are less known and have less diffused (e.g. second-generation biomass power, enhanced geothermal systems, offshore wind, or emerging PV technologies).

Given that the models control for RE policies, the real effectiveness of GEF and CDM in reducing GHG may be underestimated, if there is an indirect effect via promotion of RE policies. Therefore, the following findings on effectiveness in inducing RE policies are relevant for estimating overall effectiveness of international climate finance in promoting RE technologies.

8.1.3 Effectiveness in inducing RE policies

Chapter 6 analyzed research question 3, which is based on theories about the role of international environmental regimes in creating rules and institutions, particularly national policies: *Has international climate finance induced developing countries to undertake renewable energy policies?* This chapter addressed this research question by using an event history model for estimating the determinants of four different types of RE policy adoption – RE targets, framework policies, feed-in tariffs and financial incentives – in 114 developing and emerging countries. The models controlled for both domestic (socio-economic, environmental and institutional) drivers and international diffusion mechanisms (learning and emulation from peers and incentives from the international level).

The model found that CDM funding has not clearly a significant effect on adoption of any of the four analyzed RE policies, although it tends to have a positive influence on all policies apart from feed-in-tariffs where it tends to have a negative influence. However, all of these influences are not significant, apart from few alternative specifications in case of targets and frameworks. On one hand, this result implies that the CDM EB's decision to still credit GHG emissions reductions even if they are enabled by national climate-friendly policies (UNFCCC, 2005b) seems to have avoided a potential perverse incentive of the CDM on RE policy adoption. On the other hand, this result also means that the CDM incentive has not proven to be strong enough to promote feed-in tariffs and financial incentives, which are seen as key for RE diffusion. Given that the CDM only covers a small part of the incremental costs of technologies – particularly wind and solar (Schneider et al., 2010) –, this result seems to be reasonable.

GEF tends to have a positive influence on all types of RE policies in the short term (first three years after funding approval) but the effect is only significant at the 10% level in case of framework policies However, even the effect on framework policies is sensitive to the model specification. In the long-term (6 years after funding approval), we find a significant effect of GEF on target and tariff adoption. These result is reasonable as GEF provides capacity building for policies, which in the short term may rather influence "soft" policies like frameworks, while an effect on more concrete or costly policies like tariffs or incentives may rather happen in the long-term, as GEF does not provide direct financing. Interestingly, development assistance for renewable energies almost significantly increases the adoption of feed-in tariffs. This may relate to targeted ODA programs to transfer knowledge on feed-in tariffs, see e.g. GIZ (2012a, 2012b).

Internal validity of the results has been backed up by estimating different lags for GEF and CDM influence, controlling for a range for domestic and international control variables and controlling for maturation with time fixed effects. Nevertheless, the ultimate decision process within a country is only approximately captured because data on national environmental pressure groups and preferences is not perfect and the complex interactions between national governments, interest groups and international actors cannot be fully modeled in a simple event history model; these interactions are case-specific and not known in detail.

External validity of the finding that CDM and GEF have hardly supported the set-up of RE policies is difficult to draw. Generalization to other countries is hardly possibly as we included all large developing countries but excluded some very small countries where data was not available. One has also to be hesitant to generalize to other types of policies or to other project types (e.g. energy efficiency and landfill gas flaring) as the economics may be different. Finally, it also difficult to predict the future impact of GEF and CDM on RE policy adoption, as framework policies may become less important and the carbon price may change. Furthermore, CDM PoAs may offer a closer link between CDM and national policies, although the liability rules for verifiers are a significant challenge for PoAs (Halbritter and Ohndorf, 2012).

8.1.4 Effectiveness of a focus on mobilizing private finance

Finally, Chapter 7 analyzed research question 4, which challenged the idea that mobilizing private finance is an effective strategy in climate policy: *How does a focus on mobilizing private finance influence the cost-effectiveness of climate finance?* This question was answered by both a theoretical and empirical analysis. In the theoretical analysis, the impact of mobilizing private finance on cost-effectiveness was analyzed under different assumptions (informed versus non-informed public institutions, cost-covering versus profit-oriented private finance). In the empirical part, data from more than 300 GEF and CDM projects were used to estimate, first, the correlation between private finance intensity and cost-effectiveness, and second, to analyze the impact of private finance intensity on cost-effectiveness when controlling for a range of covariates.

The theoretical analysis concludes that a focus of climate finance on mobilizing private finance will tend to decrease cost-effectiveness of climate policy as long as public institutions are well informed about GHG benefits of mitigation options and would select the most cost-effective options without private finance as policy goal. This is because there are trade-offs between private finance intensity and GHG mitigation, as private investors will receive income beyond climate finance in case of mitigation projects. A focus on private finance would also decrease *effectiveness* in reducing GHG emissions, if the public institution is well-informed about effectiveness per unit of public finance (and could, therefore, just select the most effective projects), or if the mobilized private finance simply consists of profit-oriented investments. If public institutions are not informed about (cost-)effectiveness of options, then a focus on mobilizing private finance will increase (cost-)effectiveness) if there is a positive correlation between private finance and (cost-) effectiveness.

The theoretical ideas are backed up by results from empirical analysis. First, there is a positive but far from perfect correlation between private finance and cost-effectiveness. This means that privately financed projects indeed tend to be cost-effective, as often found in the literature. Therefore, in case of a non-informed public institution that would otherwise randomly select projects, a focus on the projects with the highest private finance intensity increases cost-effectiveness. However, in case of a well-informed public institution that is able to select the most cost-effective options, a focus on the projects with the highest private finance intensity will clearly decrease cost-effectiveness. Second, if we estimate the determinants of cost-effectiveness with regression models, private finance remains a significant predictor but can only explain a small part of the variation while the project types can explain a large part. This means for a public institution aiming at cost-effectiveness – if it has no detailed information on single projects – that it should first select the most cost-effective project types, and only select projects with more private finance if it compares very similar projects (e.g. two wind power plants in China with an installed capacity of 50 megawatts).

Are these results internally and externally valid? Internal validity of the results is supported by the fact that the models control for many covariates and also for potential heteroskedasticity. However, one challenge for internal validity is data quality: as we derive the data on cost-effectiveness from project documents, it may be the case that some projects are actually BAU projects so supporting them is very ineffective. Support for BAU projects could be particularly challenging for one of our conclusions: that private finance intensity is positively correlated with cost-effectiveness. This conclusion may be challenged as projects with high private finance intensity are more likely to be BAU: projects with very high private investments compared to the "needed" public finance (e.g. large hydro power) are more likely to be BAU than projects where a high percentage of investment costs is to be covered by public finance (e.g. solar power). Therefore, support for BAU projects is a challenge for the conclusion that private finance and cost-effectiveness of support is positively related, and it further supports the thesis that a focus on private finance may also reduce the cost-effectiveness of climate finance. One of our public administration interviewees suggested that the risk of supporting BAU projects also exists if substantial public finance is claimed to be "mobilized". This is particularly important for the case of GEF and the CIFs that claim to mobilize substantial co-finance (CIF, 2010; GEF, 2010b), which does not only include private finance but also loans from MDBs and bilateral grants.

External validity of the results differs according to the direction of generalization: generalization of the results to all CDM and GEF projects can be justified on the ground that we have selected a representative sample. Generalization to all climate change projects is more questionable, as specific projects (e.g. nuclear power, avoided deforestation) are not part of the sample as they are excluded by GEF and the CDM. However, the risks that these project types may substantially change the results are minor as the correlation between private finance and cost-effectiveness cannot become perfect by adding further projects, so the trade-off will remain, and the positive impact of private finance on cost-effectiveness should hardly change if we keep controlling for the project type in the regression. Finally, generalization to other climate finance channels apart from GEF and CDM is only partly possible: while similar patterns, such as non-perfect correlation between private finance and GHG reduction, will probably also occur in case of other public climate finance programs, we may see a higher correlation between private finance and cost-effectiveness in some of the more private-sector oriented tools, such as loans, guarantees and equity instruments of development banks.

8.2 Policy implications and further research

The results have various implications for policy makers, and also leave some gaps for further research. We will first discuss policy implication and remaining research gaps in three areas (provision of climate finance, effective spending and private finance mobilization) and, finally, line out some key policy recommendations.

8.2.1 Policy implications and further research on provision of climate finance

In case of provision of climate finance, it seems relevant that negotiators clearly define the amount of climate finance to be provided – similar to the need for clearly defined commitments on GHG emissions reductions. Definitions on climate finance should not only include the amount, timing and type of finance (investment finance, grants or concessional loans) but also the baseline to make sure that all countries have a similar understanding of the term "new and additional". At best, countries would agree on a common baseline definition to make finance numbers comparable, and according to our analysis "above pre-defined development assistance and climate finance" and "new sources" would be suited to both enable an increase in climate finance without diversion of development assistance. As second best solution, industrialized countries may attach an own baseline to their financing. During the last two years, policy makers have undertaken first steps in this direction: several countries have begun to define baselines for their "new and additional" finance during the fast-start finance period (e.g. Canada, Iceland, Liechtenstein, New Zealand, Switzerland, see Ciplet et al. (2011)). Furthermore, the biennial reporting guidelines, as adopted by the COP in Durban (UNFCCC, 2011a), ask industrialized countries to describe how they determine that finance is "new and additional". This new requirement for industrialized countries is important given that major contributors (US and Japan) have never described their baseline for "new and additional"; it may also allow independent researchers to assess whether development assistance is diverted (as seems to be the case under most current definitions).

The study on the term "new and additional" finance has also revealed – apart from the need to clearly define climate finance terms – that new sources of finance may be needed to overcome the trade-off between development and climate finance under a budget constraint. Such new sources are e.g. carbon taxes, air transport levies or auctioning of emission rights. Given that setting up new funding sources will take time (e.g. the introduction of new taxes will require parliamentary approval), policy makers may have to plan in advance, by setting up these sourcing instruments early in order to be prepared when both actions on mitigation and finance are stepped up in the future (e.g. 2015 or 2020). From a research side, the country-internal dynamics of providing climate finance, e.g. the debates on how much climate finance should be provided and whether it should aim at mitigation, sustainable development or political self-interests are not yet fully understood. An interesting case study could be to explore how Germany decided to use part of its revenues from auctioning emissions allowances as new source of international climate finance.

8.2.2 *Policy implications and further research on effective spending of climate finance for RE*

Implications for policy makers on the effective spending of climate finance differ for market-based and public climate finance. In case of market-based international climate finance (carbon price), policy makers may have to become aware that the CDM does not fully fulfill its role of assisting industrialized countries in meeting their GHG targets under the Kyoto Protocol in a cost-effective way. This is because the CDM support for renewable energies leads to substantially lower GHG emissions reductions than certified, so CDM projects are not always more cost-effective than mitigation projects in the North. If the results are true that CDM support only enables biomass energy projects, while having no impact on other RE[102], then more than 80% of CDM certificates from RE and at least 30% of expected CDM credits until 2012 are representing GHG emissions reductions that would have occurred without the CDM. Therefore, the CDM undermines the environmental integrity of the Kyoto Protocol – agreed GHG targets are only met on a legal but not a real physical basis. This may imply that CDM reforms are needed, e.g. registration could be restricted to project types where CDM support is vital or to cases where non-CDM funding from the credit buyers assures that incremental costs of RE technologies can be met. However, no CDM reform will overcome the challenge of asymmetric information between project owner and verifiers on the counterfactual GHG emission situation without CDM support, so

[102] This is clearly a simplification, as our results are only an estimate on the average impact of the CDM on RE diffusion. Some biomass projects may not be effective, while some geothermal, wind and solar projects may be effective.

with every CDM reform (e.g. also with standardized baselines) funding will flow to BAU projects, while transaction costs for verifying emission reductions remain substantial.

Therefore, it seems to be warranted to use the carbon price signal not in relation to *counterfactual GHG emissions reductions* but in relation to *factual GHG emissions*. This may be undertaken with very well-known instrument: e.g. a carbon tax or an ETS that obliges emitters to render an emission allowance per tonne of CO_2. Clearly, the question arises, how these instruments can be introduced and linked to international climate finance. In case of a carbon tax, international climate finance may both be used for capacity building or as compensation for domestic economic losses of a carbon tax (at best this compensation would be earmarked for climate change programs). In case of an ETS, international climate finance may be used for capacity building (as currently conducted by the World Bank Partnership for Market Readiness) or for purchasing emission credits in the South, e.g. by linking an existing industrialized country ETS with a developing country ETS. While such a use of international climate finance will certainly involve some economic losses for industrialized countries (e.g. if a developing country establishes an ETS with GHG caps above projected emissions), it may help to set-up national policies that introduce a carbon price for a large part of GHG emissions, which is seen a cornerstone for successful climate policy by many (e.g. Nordhaus, 2006; Stern, 2007). If a national ETS is politically not acceptable in developing countries, sectoral emission trading (Gavard et al., 2011), sectoral crediting (Schneider and Cames, 2009) or CDM standardized baselines (Hayashi et al., 2010; Spalding-Fecher and Michaelowa, 2013) may be used as intermediary steps. The concrete design of these mechanisms and the effectiveness of the first pilot approaches (e.g. the recently announced EU support for the pilot ETS in China) are interesting areas for further research.

In case of public climate finance, such as the GEF, policy makers may have to consider that climate finance may actually be less effective than officially claimed, for which there are several reasons: intended overestimations due to political pressure, asymmetric or missing information on the real drivers of low-carbon investments, deficient calculation methodologies and, last but not least, the underachievement of planned results, e.g. the promotion of national RE policies. What are potential remedies, at least for the case of GEF, which we have studied? One idea is improve the projection and review of GHG emissions reductions. While this is technically challenging as many uncertainties are involved (Mee et al., 2008), a more consistent estimation method with transparency on assumptions, and a review of the results may help to improve the understanding of project effectiveness, and thereby, promote learning. A second remedy may be to increase competition between countries for funding. Until now, GEF funding is allocated according to a fixed allocation formula, which does take into account the emission reduction potential and the past environmental policy performance (GEF, 2010c), but not the actual climate policy plans of each country. A stronger alignment with the ambition and the own contribution of a country may be needed. Some scholars would even go as far as saying that, once a uniform carbon price is in place (and ETS in North and South are linked), any public funding schemes, such as the GEF, become obsolete and will reduce cost-effectiveness of international climate finance. However, public finance may still be needed for correcting market failures, as explained in the following paragraph.

While an ETS or carbon taxes may be the cornerstone of a climate policy for developing countries that creates transformational change, additional policies or finance may be needed to overcome market failures that cannot be alleviated by a carbon price: e.g. support for research and development to overcome the problem of sub-optimal technology development in the situation of knowledge spill-over (Jaffe et al., 2005), feed-in tariffs or other quantity instruments for renewable energies to improve learning-by-using, create economies of scale and, thereby, reduce long-term technology costs (Junginger et al., 2005; Nemet, 2009) and, as already discussed in chapter 3.3.2, financial incentives, energy standards or information instruments for unlocking energy efficiency potential that is hindered by asymmetric information or very high information costs (Jaffe and Stavins, 1994; Sorrell et al., 2004; Schleich and Gruber, 2008). It is certainly very difficult to assess, when such public policies beyond a carbon price are warranted to be supported by international climate finance. For answering this question, detailed case studies are needed, opening up a wide range of potential research. Particularly, an open question is whether and when international public finance may not only support technology-pull policies (e.g. feed-in tariffs, standards) as conducted by the GEF, but also technology-push policies (e.g. research & development). Finally, researchers and policymakers may not only have to consider *whether and when* support for national policies is warranted but also *how* international climate finance can support the set-up of policies.

In case of climate finance support for national policies, policy maker may have to acknowledge that neither existing capacity building (GEF) nor minor financial payments (CDM) have proven to be successful in driving incentive-based RE policies, such as financial incentives and FITs. This may imply that policymakers, including the ones governing the Green Climate Fund, may have to look for new ways to support RE policies via international climate finance. There are at least three ideas that could be explored. First, financial incentives and capacity building may be used in joint programs to overcome financial, information and regulatory barriers at the same time. Second, different climate finance streams may be combined, e.g. carbon market and public finance, to cover a larger part of the costs of FITs (Castro et al., 2011b). Third, international climate finance may strategically be targeted to support countries that undertake ambitious climate policies and measures. Some related ideas are extra funding for countries that introduce ambitious cap-and-trade systems (Wagner et al. 2009) and budget support for climate change (Horstmann et al., 2009), which may be used to integrate climate change in development plans and implement policies. In case of budget support, the international community would not impose specific policies but offer capacity building and review the results, similar to the planned MRV of supported NAMAs (UNFCCC, 2010). International climate finance could be channeled via national funding entities (Gomez-Echeverri, 2010) that coordinate the national spending for programs. All of these ideas would strengthen host country ownership, which is one of the key principles of aid effectiveness (OECD, 2008).

However, for all of these ideas for supporting national policies via international climate finance – and particularly for areas beyond RE – evidence is missing or scarce, so empirical research may be needed. First, to start with, empirical cases studies of RE policy adoption may help to improve the understanding of the complex national decision process, and how international climate finance influences "soft" policies but fails to enable costly FITs or financial incentives. Such case studies may also explore, whether and how ODA programs, such as the one GIZ (2012a, 2012b), have influenced FIT adoption. Second, both quantitative models (similar to our RE study) and case studies may explore whether GEF, CDM and other climate finance programs have been successful in enabling policies in the energy efficiency field. Third, researchers may explore newer international climate finance programs that have tried to focus more on the national policy level, e.g. the Climate Investment Funds, which aim to improve country ownership and alignment with national planning (CIF, 2011b), programmatic CDM, which is more closely linked to policies than project CDM, and finally new national funds, such as the Bangladesh Climate Change Resilience Fund and the Indonesia Climate Change Trust Fund.

A remaining research question is why climate finance continues to flow to non-effective programs, even when there is ever-growing empirical evidence that many programs are not working as planned. Potential explanations are institutional inertia, self-interests of policy makers, political compromises as results of bargaining between countries and a knowledge gap between the research and political community. Interviews with policy makers may help to address this research gap.

8.2.3 Policy implications and further research on private finance mobilization

For policy makers, the private finance results imply that, from a climate change mitigation perspective, they should refrain from seeing private investments as primary goal of climate finance, and better focus climate finance on projects and programs reducing GHG emissions most effectively. Private finance may be used as project selection criteria if very similar projects are compared and if no better information on (cost-)effectiveness is available. The simplest way to achieve GHG emission reductions cost-effectively is to set a price on carbon emission, via a carbon tax, ETS and, if politically needed, with an intermediary tool between CDM and a national ETS. With such a carbon price, the private sector would invest by itself in the most cost-effective mitigation technologies and opportunities (assuming no market failures), and private finance is mobilized on its own. Any deviation away from a pure carbon price signal to an instrument that primarily aims at mobilizing private investments in low-carbon technologies will lead to less effective results in terms of GHG mitigation, as long as the mobilized private finance does not cover abatement costs. If policy makers realize that some cost-effective low-carbon investments are not undertaken even under a carbon price (due to market failures), an analysis of the investment barriers and the use of complementary policy instruments (e.g. capacity building tools, regulatory change and in some cases public investment or guarantees to buy down risks) may be needed. However, such a policy will only be (cost-)effective if it focuses on the investment barriers of the most (cost-)effective projects, and not on the investment barriers of the projects mobilizing most private investments. Evaluating whether and which of such complementary finance tools is needed requires detailed scrutiny of specific cases by policy makers.

The result on private finance mobilization leave at least two research gaps open. First, has public climate finance ever induced the private sector to take over costs of mitigation (meaning that the private sector takes over costs for which it is not compensated with carbon credit sales or public subsidies)? Second, are private finance and effectiveness in reducing GHG emissions more strongly aligned in case of finance facilitating tools of the development banks (e.g. public-private equity funds, credit lines, guarantees)?

8.3 Key policy recommendations

As final part of this thesis, we can derive at least five key policy recommendations related to the effectiveness of international climate finance:

(1) Policy makers have to *carefully define major climate finance terms*, such as “new and additional”, to allow for transparency, common expectations and assessment of compliance. The choice of the definitions may have major implications on the level of climate finance and related effectiveness.

(2) Policy makers have to be more careful in using carbon market tools that require assessment of counterfactual emission reductions, such as in the CDM. *Transformation of the carbon price signal* from supporting counterfactual GHG emission reductions to *pricing factual GHG emissions* is a key endeavor for international climate finance in the next years.

(3) Policy makers have to *strengthen the assessment of public climate finance effectiveness* in order to avoid overestimations. For this, detailed and transparent GHG calculation methodologies and the review of the results are needed, also in case of the new Green Climate Fund. An important ingredient of effective public finance may be a detailed case-specific assessment on whether a market failure is indeed given, and which programs are best suitable for removing this market failure. Results from existing and future academic research may be helpful in this regard.

(4) As existing climate finance has not been very successful in supporting the set-up of national climate policies as key drivers for a low-carbon transformation, new *ways to support national policies via*

international climate finance have to be explored, e.g. by combining price signals with capacity building or by strategically supporting developing countries that undertake ambitious measures.

(5) While the private sector is often cost-effective in implementation and will be required as key provider of low-carbon investments, public institutions should *be careful that a focus on projects mobilizing most private finance does not exclude some of the most (cost-)effective mitigation options*, such as non-CO_2 reducing projects or publicly owned programs in China. As long as public institutions have enough information, they can achieve more (cost-)effective results when focusing international climate finance on projects and programs that reduce GHG emissions most (cost-)effectively.

9 Literature

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10 Annexes

10.1 Conducted expert interviews

Position of interviewee	Institution	Date of interview
CDM expert	International NGO, Peru	29/10/2010
Senior operational officer	World Bank, USA	30/11/2010
Senior environment specialist	World Bank, USA	30/11/2010
Senior official	Global Environment Facility, USA	07/12/2010
CDM administrator, delegation member in the climate negotiations	Government, Vietnam	08/12/2010
University researcher, delegation member in the climate negotiations	University, Peru	09/12/2010
Director	National funding institution, Peru	09/12/2010
Climate change expert	European country's embassy, Peru	03/02/2011
Former senior expert on energy efficiency	Ministry of Energy & Mines, Peru	04/02/2011
Expert for CDM Programmes of Activities	Private company, Germany	23/03/2011
Senior Project Manager, CDM fund	Kreditanstalt für Wiederaufbau, Germany	29/03/2011
Head of sustainability	International Finance Corporation, USA	08/07/2011
Senior program director, private finance specialist	International NGO, Switzerland	14/07/2011
Head of climate fund	European Investment Bank, Luxembourg	15/07/2011
Expert for clean tech venture capital funds	Asian Development Bank, Philippines	15/07/2011
Manager, clean energy finance	United Nations Environment Programme, Kenya/France	23/07/2011
Senior expert, public-private climate fund	Department for International Development, United Kingdom	29/07/2011
Senior expert, public-private climate fund	Kreditanstalt für Wiederaufbau, Germany	29/07/2011
Senior official, member of the climate negotiations delegation	Government, Chile	22/09/2011
University researcher, CDM official	University & Government, China	21/09/2011
Senior expert, delegation member in the climate negotiations	Federal Office for the Environment, Switzerland	20/08/2012
Senior expert, delegation member in the climate negotiations	State Secretariat for Economic Affairs, Switzerland	12/09/2012

10.2 Annex to Chapter 5 (Drivers for renewable energy diffusion)

10.2.1 *Summary statistics (only observations with positive dependent variable)*

Biomass power	Obs	Mean	Std. Dev.	Min	Max
Dependent variable	503	2.87	3.65	0.01	26.29
Lagged DV	503	2.73	3.45	0.00	26.29
CDM	503	4.56	38.13	0.00	562.23
GEF	503	4.53	28.34	0.00	295.78
Knowledge	503	0.00	0.01	0.00	0.14
Policies	503	0.04	0.22	-1.00	2.00
Oil imports	503	0.40	4.03	-24.98	1.19
GDP per capita	503	4.24	3.26	0.37	18.45
Nat. resources	503	0.76	0.70	0.05	3.52
ODA	503	0.04	0.18	0.00	1.56
Kyoto Protocol	503	1.35	2.19	0.00	8.71
Electricity use	503	0.00	0.00	0.00	0.01
Financial mark.	485	0.44	0.27	0.11	1.69
FDI	503	0.03	0.03	-0.08	0.22
Develop. Loans	344	0.00	0.00	0.00	0.00
Policies (Altern.)	503	0.04	0.23	0.00	2.00
Oil price	503	38.09	18.16	17.32	92.28
Grid stability	501	385.74	312.41	0.00	999.05

Geothermal power	Obs	Mean	Std. Dev.	Min	Max
Dependent variable	164	14.02	13.25	0.00	56.77
Lagged DV	164	13.84	13.46	0.00	56.77
CDM	164	13.39	69.43	0.00	427.12
GEF	164	24.94	94.76	0.00	481.96
Knowledge	164	0.00	0.00	0.00	0.01
Policies	164	0.34	0.88	0.00	3.00
Oil imports	164	0.59	0.71	-1.39	1.11
GDP per capita	164	3.18	2.52	0.16	8.80
Nat. resources	164	0.00	0.00	0.00	0.00
ODA	164	1.31	2.51	0.00	11.07
Kyoto Protocol	164	1.13	2.17	0.00	9.73
Electricity use	164	0.00	0.00	0.00	0.00
Financial mark.	163	0.43	0.21	0.15	1.16
FDI	164	0.02	0.02	-0.03	0.09
Develop. Loans	110	0.00	0.00	0.00	0.00
Policies (Altern.)	164	0.20	0.40	0.00	1.00
Oil price	164	38.00	19.41	17.32	92.28
Grid stability	161	331.00	262.99	41.25	990.46

Hydro power	Obs	Mean	Std. Dev.	Min	Max
Dependent variable	1625	172.26	488.58	0.03	5346.34
Lagged DV	1625	174.61	503.88	0.00	5770.18
CDM	1625	5.84	56.85	0.00	961.04
GEF	1625	4.25	39.28	0.00	666.15
Knowledge	1625	0.01	0.04	0.00	0.70
Policies	1625	0.11	0.53	0.00	3.00
Oil imports	1625	-2.03	18.67	-361.19	2.94
GDP per capita	1625	2.51	3.33	0.11	27.51
Nat. resources	1625	1.63	1.42	0.01	9.41
ODA	1625	5.37	14.38	0.00	171.55
Kyoto Protocol	1625	0.89	1.84	0.00	9.93
Electricity use	1619	0.00	0.00	0.00	0.01
Financial mark.	1547	0.40	0.29	0.00	2.32
FDI	1590	0.03	0.05	-0.21	0.90
Develop. Loans	1062	0.00	0.00	0.00	0.01
Policies (Altern.)	1625	0.06	0.24	0.00	1.00
Oil price	1625	37.33	17.84	17.32	92.28
Grid stability	1612	476.45	348.77	0.21	1000.00

Solar power	Obs	Mean	Std. Dev.	Min	Max
Dependent variable	125	0.08	0.19	0.00	1.05
Lagged DV	125	0.07	0.17	0.00	1.05
CDM	125	0.00	0.00	0.00	0.00
GEF	125	21.23	73.52	0.00	396.67
Knowledge	125	0.02	0.04	0.00	0.21
Policies	125	0.03	0.31	-1.00	2.00
Oil imports	125	0.35	0.69	-0.96	1.04
GDP per capita	125	4.72	4.78	0.18	18.45
Nat. resources	125	5.22	0.65	3.10	6.10
ODA	125	0.17	0.80	0.00	4.37
Kyoto Protocol	125	1.73	2.13	0.00	7.93
Electricity use	125	0.00	0.00	0.00	0.01
Financial mark.	125	0.67	0.44	0.19	1.80
FDI	125	0.02	0.02	-0.01	0.09
Develop. Loans	101	0.00	0.00	0.00	0.00
Policies (Altern.)	125	0.13	0.46	0.00	2.00
Oil price	125	45.40	21.05	17.32	92.28
Grid stability	123	136.38	113.23	0.00	490.47

Wind power	Obs	Mean	Std. Dev.	Min	Max
Dependent variable	240	0.61	1.17	0.00	6.23
Lagged DV	240	0.52	1.06	0.00	5.80
CDM	240	6.23	29.76	0.00	255.39
GEF	240	11.75	39.99	0.00	247.18
Knowledge	240	0.02	0.04	0.00	0.38
Policies	240	0.16	0.50	0.00	3.00
Oil imports	240	0.39	0.73	-2.09	1.18
GDP per capita	240	4.99	4.85	0.44	27.51
Nat. resources	240	4.71	0.92	2.60	6.60
ODA	240	0.18	0.46	0.00	4.06
Kyoto Protocol	240	1.53	2.12	0.00	8.13
Electricity use	240	0.00	0.00	0.00	0.01
Financial mark.	240	0.58	0.34	0.15	1.69
FDI	240	0.03	0.03	-0.01	0.22
Develop. loans	204	0.00	0.00	0.00	0.00
Policies (Altern.)	240	0.21	0.52	0.00	3.00
Oil price	240	43.98	20.31	17.32	92.28
Grid stability	236	286.36	287.82	0.24	916.18

10.2.2 Correlation tables (only observations with positive dependent variable)

Biomass power

	Dependent variable	Lagged DV	CDM	GEF	Knowledge	Policies	Oil imports	GDP per capita	Nat. resources	ODA	Kyoto Protocol	Electricity use	Financial mark.	FDI	Develop. loans	Policies (Altern.)	Oil price	Grid stability
Dependent var.	1.00																	
Lagged DV	0.94	1.00																
CDM	0.38	0.37	1.00															
GEF	-0.06	-0.06	-0.01	1.00														
Knowledge	-0.06	-0.06	0.00	-0.02	1.00													
Policies	-0.03	-0.03	0.00	-0.01	0.20	1.00												
Oil imports	0.16	0.15	0.04	0.05	0.03	0.04	1.00											
GDP per capita	-0.25	-0.24	-0.04	-0.04	0.47	0.11	-0.11	1.00										
Nat. resources	0.21	0.22	0.10	-0.11	-0.04	0.00	-0.28	-0.05	1.00									
ODA	0.13	0.11	-0.01	-0.03	-0.04	-0.03	0.06	-0.17	0.05	1.00								
Kyoto Protocol	0.15	0.16	0.28	0.03	0.12	0.15	0.08	0.14	-0.04	0.00	1.00							
Electricity use	-0.21	-0.21	-0.02	0.01	0.20	0.09	-0.21	0.81	-0.22	-0.15	0.11	1.00						
Financial mark.	-0.06	-0.07	0.02	0.32	0.16	0.29	0.19	0.21	-0.25	-0.03	0.17	0.27	1.00					
FDI	-0.05	-0.05	0.03	0.04	0.00	0.00	0.15	0.03	-0.05	0.04	0.28	0.15	0.33	1.00				
Develop. Loans	-0.12	-0.12	0.01	-0.01	-0.03	-0.01	0.02	-0.10	-0.12	-0.04	-0.03	-0.11	0.04	-0.03	1.00			
Policies (Altern.)	0.01	-0.01	0.02	-0.01	0.41	0.85	0.05	0.22	0.01	-0.03	0.21	0.15	0.29	-0.01	-0.02	1.00		
Oil price	0.06	0.07	0.23	0.02	0.21	0.21	0.06	0.18	-0.03	-0.07	0.76	0.11	0.18	0.24	0.03	0.29	1.00	
Grid stability	-0.02	-0.01	-0.05	-0.14	-0.05	0.00	-0.09	-0.09	0.43	-0.10	-0.08	-0.36	-0.29	-0.12	0.01	0.03	-0.07	1.00

Geothermal power

	Dependent variable	Lagged DV	CDM	GEF	Knowledge	Policies	Oil imports	GDP per capita	Nat. resources	ODA	Kyoto Protocol	Electricity use	Financial mark.	FDI	Develop. loans	Policies (Altern.)	Oil price	Grid stability
Dependent var.	1.00																	
Lagged DV	0.98	1.00																
CDM	0.15	0.14	1.00															
GEF	0.42	0.41	-0.01	1.00														
Knowledge	-0.17	-0.16	-0.02	-0.02	1.00													
Policies	0.48	0.47	0.07	0.70	0.07	1.00												
Oil imports	0.40	0.34	0.10	0.15	0.03	0.08	1.00											
GDP per capita	-0.39	-0.35	-0.06	-0.15	0.12	-0.17	-0.49	1.00										
Nat. resources	0.48	0.47	0.23	0.08	-0.05	0.16	0.10	-0.05	1.00									
ODA	0.63	0.58	-0.07	0.56	-0.06	0.56	0.06	-0.35	0.06	1.00								
Kyoto Protocol	0.12	0.09	0.61	-0.09	-0.04	0.05	0.06	0.19	0.34	-0.26	1.00							
Electricity use	-0.43	-0.29	-0.06	-0.19	0.01	-0.09	-0.50	0.89	-0.11	-0.36	0.05	1.00						
Financial mark.	-0.18	-0.19	-0.01	0.07	0.00	0.06	0.08	-0.16	-0.15	0.05	0.04	0.10	1.00					
FDI	-0.08	-0.07	0.00	-0.03	0.00	-0.02	0.07	0.03	-0.07	-0.07	0.17	0.19	0.04	1.00				
Develop. loans	-0.09	-0.08	-0.05	-0.04	0.13	0.09	-0.31	-0.12	-0.07	0.24	-0.14	-0.12	0.05	-0.05	1.00			
Policies (Altern.)	0.47	0.44	0.24	0.46	0.16	0.77	0.09	-0.19	0.15	0.41	0.19	-0.11	0.08	-0.02	0.22	1.00		
Oil price	0.04	-0.01	0.40	-0.11	0.18	-0.01	0.09	0.21	0.01	-0.23	0.66	0.11	0.08	0.15	-0.02	0.20	1.00	
Grid stability	-0.03	-0.01	-0.09	-0.12	-0.03	-0.05	0.14	-0.13	-0.23	-0.15	-0.07	-0.41	-0.36	-0.12	-0.21	-0.09	-0.04	1.00

Hydro power

	Dependent variable	Lagged DV	CDM	GEF	Knowledge	Policies	Oil imports	GDP per capita	Nat. resources	ODA	Kyoto Protocol	Electricity use	Financial mark.	FDI	Develop. loans	Policies (Altern.)	Oil price	Grid stability
Dependent var.	1.00																	
Lagged DV	0.99	1.00																
CDM	-0.02	-0.02	1.00															
GEF	-0.02	-0.02	0.01	1.00														
Knowledge	-0.03	-0.03	0.00	0.14	1.00													
Policies	0.11	0.12	-0.02	0.00	-0.02	1.00												
Oil imports	0.04	0.04	0.02	0.02	0.02	-0.07	1.00											
GDP per capita	-0.13	-0.13	0.00	-0.05	0.22	-0.08	-0.09	1.00										
Nat. resources	0.17	0.17	0.09	0.04	-0.03	0.14	-0.04	-0.12	1.00									
ODA	0.11	0.12	-0.03	-0.02	-0.03	0.13	0.04	-0.15	0.36	1.00								
Kyoto Protocol	-0.04	-0.03	0.30	0.10	0.11	-0.01	-0.08	0.12	0.05	-0.13	1.00							
Electricity use	0.09	0.08	-0.02	-0.02	0.20	-0.05	0.03	0.73	-0.18	-0.19	0.08	1.00						
Financial mark.	-0.15	-0.15	0.03	-0.05	0.03	-0.05	0.12	0.30	-0.11	-0.09	0.11	0.31	1.00					
FDI	0.01	0.02	0.01	0.01	0.06	0.06	-0.14	-0.01	0.03	0.01	0.13	0.04	0.07	1.00				
Develop. loans	-0.03	-0.03	-0.01	0.57	-0.02	-0.03	0.02	-0.02	0.03	-0.02	0.05	-0.03	0.03	-0.02	1.00			
Policies (Altern.)	0.08	0.09	-0.01	0.02	-0.02	0.83	-0.04	-0.07	0.15	0.12	0.10	-0.04	0.00	0.02	-0.03	1.00		
Oil price	-0.03	-0.02	0.18	0.09	0.17	0.02	-0.04	0.06	0.01	-0.14	0.73	0.09	0.14	0.21	0.05	0.10	1.00	
Grid stability	0.36	0.36	0.01	0.04	-0.09	0.14	0.02	-0.24	0.44	0.21	-0.06	-0.32	-0.37	-0.06	0.04	0.12	-0.06	1.00

Solar power

	Dependent variable	Lagged DV	CDM	GEF	Knowledge	Policies	Oil imports	GDP per capita	Nat. resources	ODA	Kyoto Protocol	Electricity use	Financial mark.	FDI	Develop. loans	Policies (Altern.)	Oil price	Grid stability
Dependent var.	1.00																	
Lagged DV	0.92	1.00																
CDM	.	.	.															
GEF	0.14	0.19	.	1.00														
Knowledge	0.13	0.01	.	0.05	1.00													
Policies	-0.04	-0.04	.	0.00	-0.01	1.00												
Oil imports	0.31	0.22	.	0.22	0.05	0.01	-0.34											
GDP per capita	-0.24	-0.26	.	-0.13	0.38	-0.04	-0.15	1.00										
Nat. resources	0.32	0.31	.	-0.01	-0.10	-0.04	0.19	-0.03	1.00									
ODA	0.13	0.16	.	-0.04	-0.07	-0.01	0.07	-0.17	0.21	1.00								
Kyoto Protocol	0.02	0.05	.	0.11	0.26	0.02	-0.45	0.17	0.00	0.26	1.00							
Electricity use	-0.22	-0.24	.	-0.21	0.20	-0.03	0.03	0.87	-0.06	-0.20	0.11	1.00						
Financial mark.	0.32	0.26	.	-0.09	0.00	0.00	-0.09	-0.15	0.00	-0.16	0.00	-0.01	1.00					
FDI	-0.26	-0.22	.	-0.03	-0.04	-0.01	0.06	-0.04	-0.09	-0.02	0.12	-0.04	0.07	1.00				
Develop. loans	-0.15	-0.13	.	-0.01	-0.06	0.11	0.04	-0.20	0.04	-0.06	-0.13	-0.22	0.08	-0.04	1.00			
Policies (Altern.)	-0.11	-0.10	.	0.04	-0.02	0.49	0.09	-0.03	-0.33	-0.01	0.19	-0.06	-0.07	-0.03	0.09	1.00		
Oil price	0.27	0.25	.	0.13	0.19	0.01	0.10	0.12	0.02	0.15	0.77	0.06	0.15	0.12	-0.15	0.20	1.00	
Grid stability	-0.08	-0.01	.	0.57	-0.10	0.06	-0.34	-0.31	-0.20	-0.06	-0.10	-0.45	-0.16	-0.05	0.06	0.09	0.00	1.00

Wind power

	Dependent variable	Lagged DV	CDM	GEF	Knowledge	Policies	Oil imports	GDP per capita	Nat. resources	ODA	Kyoto Protocol	Electricity use	Financial mark.	FDI	Develop. loans	Policies (Altern.)	Oil price	Grid stability
Dependent var	1.00																	
Lagged DV	0.95	1.00																
CDM	0.33	0.31	1.00															
GEF	0.31	0.24	-0.02	1.00														
Knowledge	-0.06	-0.05	-0.02	-0.03	1.00													
Policies	0.02	0.01	0.05	-0.03	-0.03	1.00												
Oil imports	0.22	0.20	0.11	0.13	0.07	-0.00	1.00											
GDP per capita	-0.18	-0.17	-0.03	-0.06	0.50	0.03	-0.01	1.00										
Nat. resources	-0.02	0.00	0.14	0.02	0.03	0.03	0.09	0.16	1.00									
ODA	0.33	0.23	0.13	-0.02	-0.05	0.04	0.05	-0.10	0.14	1.00								
Kyoto Protocol	0.16	0.13	0.41	-0.08	0.17	0.06	-0.41	0.10	-0.07	0.16	1.00							
Electricity use	-0.20	-0.19	-0.01	-0.13	0.25	-0.02	0.26	0.80	0.05	-0.12	0.10	1.00						
Financial mark.	-0.02	-0.03	0.06	0.00	0.05	0.15	0.16	0.39	0.20	0.15	0.00	0.21	1.00					
FDI	0.12	0.11	0.02	0.07	-0.02	-0.03	0.04	0.04	0.10	0.00	0.25	0.10	0.34	1.00				
Develop. loans	0.12	0.14	0.25	-0.03	-0.05	-0.01	0.03	-0.10	-0.12	0.37	0.15	-0.17	0.09	-0.03	1.00			
Policies (Altern.)	0.15	0.11	0.18	-0.05	-0.02	0.64	0.03	0.00	-0.04	0.06	0.26	-0.05	0.14	-0.04	-0.01	1.00		
Oil price	0.21	0.17	0.27	0.04	0.20	0.08	0.08	0.17	-0.04	0.19	0.76	0.08	0.12	0.36	0.11	0.27	1.00	
Grid stability	0.07	0.10	-0.12	-0.04	-0.11	0.08	0.06	-0.20	-0.42	-0.09	0.01	-0.38	-0.45	-0.05	-0.02	0.10	0.04	1.00

10.2.3 Biomass power: alternative specifications and sensitivity analyzes

BIOMASS	Selection model Logit with clustered SE		Blundell-Bond (BB), One step, robust SE , w/o control		Fixed effects, robust SE		Blundell-Bond (BB) GMM system model, One step, robust SE	
	dy/dx	SE	Coeff	SE	Coeff	SE	Coeff	SE
GEF_L1-3	-0.004	(0.003)	0.000	(0.002)	-0.005	(0.019)	0.000	(0.002)
GEF_L4-6	-0.000	(0.002)	-0.001	(0.001)	0.002	(0.003)	-0.001	(0.001)
GEF_L7-9	-0.000	(0.003)	-0.001	(0.001)	0.002	(0.003)	-0.001	(0.002)
Year FE	Yes		yes		Yes		Yes	
N	2182		503		503		503	
Groups	133		36		36		36	
F-/Wald-test	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(F-test, p-value)	0.0	(Wald, p-value)
Various stats	0.08	(Pseudo-R^2)	0.85	(AR2, p-value)	0.84	(R^2)	0.95	(AR2, p-value)
Hansen test			1.00				1.00	
# instruments			288				409	

Not displayed: Control variables +lagged DV for Random effects and BB; endog. variables in BB: CDM, GEF, ODA, policies

BIOMASS	Blundell-Bond GMM system model, One step, robust SE; ***CDM Lag1***		Blundell-Bond GMM system model, One step, robust SE; ***CDM Lag1-2***		Blundell-Bond GMM system model, One step, robust SE; ***GEF Lags 1-6***		Blundell-Bond GMM system model, One step, robust SE; ***GEF Lags 1-2***	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
CDM	0.029	(0.002) ***	0.017	(0.005) ***	0.017	(0.005) ***	0.017	(0.005) ***
GEF	-0.000	(0.001)	-0.001	(0.001)	-0.000	(0.001)	0.006	(0.016)
Year dummies	Yes		Yes		Yes		Yes	
N	503		482		503		482	
Groups	36		36		36		36	
F-/Wald-test	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)
Various tests	0.57	(AR2, p-value)	0.96	(AR2, p-value)	0.96	(AR2, p-value)	0.96	(AR2, p-value)
Hansen test	1.0		1.0		1.0		1.0	
# instruments	387		387		387		386	

Not displayed: Lagged DV + control variables; Endogenous variables: CDM, GEF, ODA, policies

BIOMASS	**Fixed effects, bias corrected, bootstrap SE**		**OLS with clustered SE**		**Random effects, robust standard errors**		**Arellano Bond GMM difference model, robust standard errors**	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Lagged DV	0.781	(0.066) ***	0.941	(0.053) ***	0.941	(0.053) ***	0.534	(0.200) ***
CDM	0.017	(0.002) ***	0.012	(0.002) ***	0.012	(0.002) ***	0.020	(0.004) ***
GEF_L1-9	0.001	(0.004)	0.000	(0.001)	0.000	(0.001)	-0.005	(0.008)
Knowledge	-2.903	(5.714)	-5.552	(3.189) *	-5.552	(3.189) *	-10.997	(11.95)
Policies	0.364	(0.167) **	0.324	(0.386)	0.324	(0.386)	0.101	(0.246)
Oil imports	-0.048	(0.060)	0.032	(0.009) ***	0.032	(0.009) ***	-0.021	(0.068)
GDP per capita	-0.027	(0.040)	-0.004	(0.012)	-0.004	(0.012)	-0.187	(0.179)
Nat. resources	0.705	(0.495)	0.299	(0.091) ***	0.299	(0.091) ***	0.489	(0.919)
ODA	0.543	(0.317) *	0.561	(0.140) ***	0.561	(0.140) ***	0.304	(0.458)
Constant			-0.244	(0.243)	-0.228	(0.262)		
Year FE	Yes		Yes		Yes		Yes	
N	503		503		503		481	
Groups	36		36		36		36	
F-/Wald-test	-	(Wald, p-value)	0.0	(F-test, p-value)	-	(Wald, p-value)	0.0	(Wald, p-value)
Various stats	-	(R^2)	0.91	(R^2)	0.91	(R^2)	0.96	(AR2, p-value)
Hansen test							1.0	
# instruments							186	

Dependent variable: tonnes of CO_2 reduced with biomass power generation, per million USD of GDP (2007 USD), assuming 500 tCO_2 reduced per GWh of renewable power production; for bias-corrected FE estimator, the xtlsdvc Stata command was used, and the BB estimator was chosen to initialize the bias correction, all independent variables assumed to be exogenous in all models.

BIOMASS	Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Lagged DV	0.715	(0.152) ***	0.705	(0.157) ***	0.691	(0.164) ***	0.660	(0.173) ***
CDM	0.017	(0.005) ***	0.016	(0.005) ***	0.017	(0.006) ***	0.017	(0.006) ***
GEF	-0.001	(0.001)	-0.001	(0.001)	0.000	(0.001)	-0.001	(0.001)
Knowledge	-5.809	(5.255)	-3.112	(5.779)			-7.575	(5.566)
Policies	0.348	(0.494)	0.385	(0.499)	0.391	(0.466)	0.347	(0.481)
Oil imports	0.075	(0.027)	0.071	(0.026) ***	0.083	(0.033) **	0.111	(0.038) ***
GDP per capita	-0.055	(0.039)	-0.068	(0.045)			-0.056	(0.044)
Nat. resources	0.602	(0.236) **	0.639	(0.251) **	0.655	(0.243) ***	0.864	(0.310) ***
ODA	0.461	(0.289)	0.381	(0.308)	0.662	(0.330) **	0.448	(0.382)
Kyoto Protocol			0.168	(0.111)				
Electricity use					-162.64	(112.44)		
Financial mark.					-0.097	(0.443)		
Develop. loans							-244.63	(225.67)
Constant	0.175	(0.481)	-0.691	(0.715)	0.071	(0.436)	0.146	(0.506)
Year FE	Yes		Yes		Yes		Yes	
N	503		503		485		344	
Groups	36		36		35		36	
F-/Wald-test	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)
Various tests	0.96	(AR2, p-value)	0.95	(AR2, p-value)	0.71	(AR2, p-value)	0.78	(AR2, p-value)
Hansen test	0.0		1.0		1.0		0.0	
# instruments	403		387		374		333	

Endogenous variable: CDM, GEF, ODA, development bank loans, policies

BIOMASS	Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Lagged DV	0.712	(0.153) ***	0.699	(0.155) ***	0.723	(0.149) ***	0.715	(0.151) ***
CDM	0.017	(0.005) ***	0.017	(0.005) ***	0.016	(0.005) ***	0.017	(0.005) ***
GEF_L1-9	-0.001	(0.001)	-0.001	(0.001)	-0.001	(0.001)	-0.001	(0.001)
Knowledge			-7.014	(4.920)	-5.832	(5.258)	-5.721	(5.358)
Policies	0.342	(0.492)	0.289	(0.485)	0.368	(0.54)	0.352	(0.497)
Oil imports	0.077	(0.033) **	0.080	(0.029) ***	0.079	(0.027) ***	0.068	(0.024) ***
GDP per capita	-0.049	(0.039)	-0.057	(0.040)	-0.054	(0.039)	-0.050	(0.038)
Nat. resources	0.592	(0.233) **	0.621	(0.246) **	0.733	(0.270) ***	0.643	(0.266) **
ODA	0.476	(0.288) *	0.468	(0.288)	0.334	(0.266)	0.472	(0.275) *
3rd education	-0.003	(0.009)						
Oil price			0.002	(0.005)				
Stability					-0.001	(0.000)		
Agricult. area							-78.834	(100.61)
Constant	0.114	(0.531)	0.595	(0.484)	0.354	(0.581)	0.189	(0.494)
Year FE	Yes		No		Yes		Yes	
N	503		503		501		503	
Groups	36		36		36		36	
F-/Wald-test	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)
Various tests	0.97	(AR2, p-value)	0.92	(AR2, p-value)	0.94	(AR2, p-value)	0.96	(AR2, p-value)
Hansen test	1.0		0.0		1.0		1.0	
# instruments	386		370		385		387	

Endogenous variable: CDM, GEF, ODA, policies

Alternative DV	CO_2 reduction via **RE per capita**		$\text{\textbf{Share of RE}}$ electricity production		CO_2 reduction via RE per GDP (**country-specific grid factors**)		CO_2 reduction via RE per GDP **(difference to last year)**	
BIOMASS	Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Lagged DV	0.797	(0.136)	0.809	(0.102) ***	0.804	(0.130) ***		
CDM	0.011	(0.005) **	0.062	(0.014) ***	0.017	(0.005) ***	0.010	(0.001) ***
GEF_L1-9	0.003	(0.003)	-0.002	(0.006)	-0.001	(0.001)	0.000	(0.000)
Knowledge	-50.176	(34.799)	-49.143	(27.189)	-3.089	(2.831)	-6.357	(4.042)
Policies	4.939	(5.095)	4.556	(4.045)	0.024	(0.145)	0.298	(0.332)
Oil imports	0.416	(0.131) ***	0.451	(0.133) ***	0.023	(0.016)	0.024	(0.011) **
GDP per capita	0.310	(0.119) ***	0.000	(0.000) **	-0.045	(0.029)	0.010	(0.011)
Nat. resources	3.920	(1.438) ***	3.687	(1.399) ***	0.047	(0.134)	0.249	(0.120) **
ODA	-0.930	(0.856)	1.025	(1.382)	0.640	(0.313) *	0.001	(0.000) ***
Constant	-2.710	(1.858)	0.466	(2.037)	0.144	(0.399)	0.256	(0.463)
Year FE	Yes		No		Yes		Yes	
N	503		501		503		503	
Groups	36		36		36		36	
Wald-test	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)
Various stat.	0.25	(AR2, p-value)	0.65	(AR2, p-value)	0.23	(AR2, p-value)	0.82	(AR2, p-value)
Hansen test	1.00	(p-value)	1.00	(p-value)	1.00	(p-value)	1.00	(p-value)
# instruments	385		388		389		217	

Note: In case of CO_2 reduction via RE per capita, CDM, GEF and ODA are standardized per capita and not per USD of GDP. Not displayed: Endogenous variables in BB: CDM, GEF, ODA, policies

Influence of number of policies in first lag & inclusion of post2012 CER value in CDM variable

BIOMASS	Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Lagged DV	0.723	(0.147) ***	0.697	(0.153) ***	0.710	(0.151) ***	0.706	(0.152) ***
CDMtil2012	0.017	(0.005) ***	0.017	(0.005) ***	0.017	(0.005) ***		
CDMtil2020							0.011	(0.003) ***
GEF_L1-9	-0.001	(0.002)	-0.001	(0.001)	-0.001	(0.001)	-0.001	(0.001)
Knowledge	-4.856	(5.593)	-7.965	(3.164) **	-7.407	(4.393) *	-5.498	(5.602)
Policies							0.330	(0.491)
L.Policy	0.743	(0.601)			0.652	(0.621)		
L.REPolicy	-0.105	(0.103)						
L.Policy_RPS			-1.308	(1.891)				
L.Policy_I&S			1.966	(1.642)				
Oil imports	0.075	(0.026) ***	0.074	(0.027) ***	0.075	(0.027) ***	0.077	(0.028) ***
GDP per capita	-0.039	(0.037)	-0.061	(0.041)	-0.056	(0.039)	-0.057	(0.038)
Nat. resources	0.539	(0.209) **	0.573	(0.236) **	0.599	(0.234) **	0.617	(0.241) **
ODA	0.487	(0.285) *	0.480	(0.304)	0.456	(0.294)	0.490	(0.288) *
Constant	0.329	(0.499)	-0.044	(0.507)	-0.027	(0.506)	0.256	(0.463)
Year FE	Yes		Yes		Yes		Yes	
N	503		503		503		503	
Groups	36		36		36		36	
Wald-test	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)
Various stat.	0.97	(AR2, p-value)	0.98	(AR2, p-value)	0.97	(AR2, p-value)	0.98	(AR2, p-value)
Hansen test	1.00	(p-value)	1.00	(p-value)	1.0	(p-value)	1.00	(p-value)
# instruments	436		383		384		386	

Note: Post-2012-CER price of 3 USD per CER assumed, which is roughly the average post-2012 CER price as reported by GTZ (2010) for the period 2005-2008. Not displayed: Endogenous variables in BB: CDM, GEF, ODA, policies; all policy variables entail the number of policies in the lag; TEN = tenders, RPS = Renewable portfolio standards, I&S=Incentives& Subsidies, FIT=Feed-in tariffs

10.2.4 Geothermal power: alternative specifications and sensitivity analyzes

GEO-THERMAL	Selection model Logit with clustered SE			Blundell-Bond (BB), One step, robust SE , w/o control		Random effects, robust SE		Blundell-Bond (BB) GMM system model, One step, robust SE	
	dy/dx	SE		Coeff	SE	Coeff	SE	Coeff	SE
GEF_L1-3	0.004	(0.002)	*	0.005	(0.002) **	0.005	(0.003) **	0.005	(0.002) **
GEF_L4-6	predicts success. perfect.			0.010	(0.002) ***	0.007	(0.004) **	0.006	(0.002) **
GEF_L7-9	predicts success. perfect.			0.004	(0.003)	0.004	(0.004)	0.004	(0.003)
Year FE	Yes			Yes		Yes		Yes	
N	2001			164		164		164	
Groups	122			10		10		10	
F-/Wald-test	0.0	(Wald, p-value)		0.0	(Wald, p-value)	-	(Wald, p-value)	0.0	(Wald, p-value)
Various stats	0.13	(Pseudo-R^2)		0.44	(AR2, p-value)	0.97	(R^2)	0.36	(AR2, p-value)
Hansen test				1.00				1.00	
# instruments				179				229	

Not displayed: Control variables +lagged DV for Random effects and BB; endog. variables in BB: CDM, GEF, ODA, policies

GEO-THERMAL	Blundell-Bond GMM system model, One step, robust SE; ***CDM Lag1***			Blundell-Bond GMM system model, One step, robust SE; ***CDM Lag1-2***			Blundell-Bond GMM system model, One step, robust SE; ***GEF Lags 1-6***			Blundell-Bond GMM system model, One step, robust SE; ***GEF Lags 1-2***		
	Coeff	SE		Coeff	SE		Coeff	SE		Coeff	SE	
CDM	-0.002	(0.007)		0.004	(0.003)		0.004	(0.003)		0.004	(0.002)	
GEF	0.006	(0.002)	***	0.007	(0.002)	***	0.004	(0.001)	***	0.011	(0.004)	***
Year FE	Yes			Yes			Yes			Yes		
N	164			157			164			157		
Groups	10			10			10			10		
F-/Wald-test	0.0	(Wald, p-value)		0.0	(Wald, p-value)		0.0	(Wald, p-value)		0.0	(Wald, p-value)	
Various tests	0.54	(AR2, p-value)		0.58	(AR2, p-value)		0.22	(AR2, p-value)		0.50	(AR2, p-value)	
Hansen test	1.0			1.0			1.0			1.0		
# instruments	229			225			226			217		

Not displayed: Lagged DV + control variables; Endogenous variables: CDM, GEF, ODA, policies

GEO-THERMAL	**Fixed effects, bias corrected, bootstrap SE**		**OLS with clustered SE**		**Fixed effects, robust standard errors**		**Arellano Bond GMM difference model, robust standard errors**	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Lagged DV	0.796	(0.024) ***	0.862	(0.045) ***	0.766	(0.037) ***	0.787	(0.021) ***
CDM	0.006	(0.004)	0.004	(0.002)	0.006	(0.004)	0.005	(0.003) *
GEF_L1-9	0.004	(0.003)	0.005	(0.002) *	0.004	(0.002) **	0.003	(0.003)
Knowledge	87.322	(415.4)	-136.51	(126.64)	42.826	(153.29)	11.427	(116.34)
Policies	-0.094	(0.519)	-0.222	(0.301)	-0.458	(0.174) *	-0.261	(0.372)
Oil imports	-0.786	(1.908)	0.390	(0.371)	-0.213	(0.683)	0.361	(0.911)
GDP per capita	-1.019	(0.830)	0.027	(0.122)	-0.675	(0.737)	-0.143	(0.371)
Nat. resources			9.509	(3.848) **	Omit.			
ODA	0.611	(0.130) ***	0.497	(0.167) **	0.727	(0.213) ***	0.618	(0.1498) ***
Constant			1.474	(1.700)	5.334	(2.772) *		
Year FE	Yes		Yes		Yes		Yes	
N	164		164		164		157	
Groups	10		10		10		10	
F-/Wald-test	-	(Wald, p-value)	0.0	(F-test, p-value)	-	(Wald, p-value)	0.0	(Wald, p-value)
Various stats	-	(R^2)	0.97	(R^2)	0.95	(R^2)	0.30	(AR2, p-value)
Hansen test							1.0	
# instruments							138	

Dependent variable: tonnes of CO_2 reduced with biomass power generation, per million USD of GDP (2007 USD), assuming 500 tCO_2 reduced per GWh of renewable power production; for bias-corrected FE estimator, the xtlsdvc Stata command was used, and the BB estimator was chosen to initialize the bias correction, all independent variables assumed to be exogenous in all models.

GEO-THERMAL	Blundell-Bond GMM system model, robust standard errors			Blundell-Bond GMM system model, robust standard errors			Blundell-Bond GMM system model, robust standard errors			Blundell-Bond GMM system model, robust standard errors;		
	Coeff	SE		Coeff	SE		Coeff	SE		Coeff	SE	
Lagged DV	0.813	(0.041)	***	0.817	(0.041)	***	0.807	(0.040)	***	0.776	(0.068)	***
CDM	0.004	(0.003)		0.003	(0.003)		0.004	(0.003)		0.002	(0.002)	
GEF_L1-9	0.007	(0.002)	***	0.007	(0.002)	***	0.007	(0.001)	***	0.016	(0.005)	***
Knowledge	-122.135	(93.69)		56.566	(99.26)					-30.085	(117.97)	
Policies	-0.244	(0.199)		-0.389	(0.197)	**	-0.278	(0.157)	*	-0.127	(0.420)	
Oil imports	0.422	(0.346)		0.502	(0.367)		0.451	(0.366)		-0.032	(0.430)	
GDP per capita	-0.053	(0.122)		-0.082	(0.126)					-0.234	(0.123)	
Nat. resources	12.606	(4.271)	***	10.979	(4.292)	***	12.028	(4.202)	***	20.996	(6.801)	***
ODA	0.528	(0.130)	***	0.541	(0.000)	***	0.001	(0.000)	***	0.349	(0.214)	
Kyoto Protocol				0.274	(0.217)							
Electricity use							-635.71	(614.44)				
Financial mark.							-0.699	(1.263)				
Develop. loans										-971.2	(827.7)	
Constant	2.146	(1.332)		0.611	(1.430)		3.045	(1.386)	**	3.100	(1.66)	**
Year FE	Yes			Yes			Yes			Yes		
N	164			164			163			110		
Groups	10			10			10			10		
F-/Wald-test	0.0	(Wald, p-value)		0.0	(Wald, p-value)		0.0	(Wald, p-value)		0.0	(Wald, p-value)	
Various tests	0.51	(AR2, p-value)		0.53	(AR2, p-value)		0.51	(AR2, p-value)		0.80	(AR2, p-value)	
Hansen test	1.0			1.0			1.0			1.0		
# instruments	164			230			228			166		

Endogenous variable: CDM, GEF, ODA, development bank loans, policies

GEO-THERMAL	Blundell-Bond GMM system model, robust standard errors			Blundell-Bond GMM system model, robust standard errors			Blundell-Bond GMM system model, robust standard errors			Blundell-Bond GMM system model, robust standard errors		
	Coeff	SE		Coeff	SE		Coeff	SE		Coeff	SE	
Lagged DV	0.811	(0.044)	***	0.815	(0.043)	***	0.813	(0.043)	***	0.833	(0.045)	***
CDM	0.004	(0.003)		0.002	(0.004)		0.004	(0.003)		0.006	(0.003)	**
GEF_L1-9	0.007	(0.001)	***	0.004	(0.002)	*	0.007	(0.001)	***	0.006	(0.001)	***
Knowledge				-175.37	(133.68)		-149.54	(122.93)		-184.4	(121.6)	
Policies	-0.171	(0.181)		-0.065	(0.277)		-0.226	(0.178)		-0.242	(0.175)	
Oil imports	0.497	(0.363)		0.552	(0.312)	*	0.348	(0.447)		0.955	(0.918)	
GDP per capita	0.020	(0.113)		-0.027	(0.120)		-0.059	(0.121)		0.012	(0.240)	
Nat. resources	13.506	(4.619)	***	12.221	(4.623)	***	12.465	(4.284)	***			
ODA	0.547	(0.150)	***	0.546	(0.147)	***	0.532	(0.131)	***	0.489	(0.134)	***
3rd education	-0.039	(0.043)										
Oil price				0.026	(0.020)							
Stability							0.000	(0.002)				
Volcanoes abs.										0.049	(0.030)	
Constant	2.676	(1.531)		-0.200	(0.691)		2.802	(1.556)	*	2.166	(2.562)	
Year FE	Yes			No			Yes			Yes		
N	164			164			161			164		
Groups	10			10			10			10		
F-/Wald-test	0.0	(Wald, p-value)		0.0	(Wald, p-value)		0.0	(Wald, p-value)		0.0	(Wald, p-value)	
Various tests	0.50	(AR2, p-value)		0.24	(AR2, p-value)		0.51	(AR2, p-value)		0.48	(AR2, p-value)	
Hansen test	1.0			1.0			1.0			1.0		
# instruments	229			212			225			229		

Endogenous variable: CDM, GEF, ODA, policies

Alternative DV	CO_2 reduction via **RE per capita**		**Share of RE** electricity production		CO_2 reduction via RE per GDP (**country-specific grid factors**)		CO_2 reduction via RE per GDP **(difference to last year)**	
GEO-THERMAL	Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Lagged DV	0.869	(0.040) ***	0.806	(0.054) ***	0.839	(0.038) ***		
CDM	0.007	(0.001) ***	0.026	(0.002)	0.003	(0.001) **	0.006	(0.002) ***
GEF_L1-9	0.001	(0.004)	0.038	(0.001) *	0.005	(0.002) ***	0.004	(0.003)
Knowledge	-279.16	(394.55)	-482.16	(552.69)	-23.878	(71.084)	90.799	(54.440) *
Policies	-0.401	(0.667)	-2.605	(1.600)	0.076	(0.174)	-0.229	(0.468)
Oil imports	1.195	(1.759)	0.194	(3.230)	-0.293	(0.231)	-0.177	(0.333)
GDP per capita	1.166	(0.741)	0.000	(0.000)	-0.162	(0.087) *	0.109	(0.103)
Nat. resources	44.155	(19.988) **	105.732	(34.513) ***	6.453	(1.542) ***	2.283	(1.865)
ODA	0.737	(0.323) **	2.153	(0.726) ***	0.427	(0.170) **	0.176	(0.134)
Constant	-3.493	(3.122)	19.056	(9.211) *	2.172	(1.038)	-0.546	(0.715)
Year FE	Yes		Yes		Yes		Yes	
N	164		161		164		164	
Groups	10		10		10		10	
Wald-test	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)
Various stat.	0.45	(AR2, p-value)	0.17	(AR2, p-value)	0.75	(AR2, p-value)	0.67	(AR2, p-value)
Hansen test	1.00	(p-value)	1.00	(p-value)	1.00	(p-value)	1.00	(p-value)
# instruments	229		224		230		187	

Note: In case of CO_2 reduction via RE per capita, CDM, GEF and ODA are standardized per capita and not per USD of GDP. Not displayed: Endogenous variables in BB: CDM, GEF, ODA, policies

Influence of number of policies in first lag & inclusion of post2012 CER value in CDM variable

GEO-THERMAL	Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Lagged DV	0.813	(0.037) ***	0.802	(0.033) ***	0.812	(0.039) ***	0.813	(0.041) ***
CDMtil2012	0.003	(0.003)	0.004	(0.003)	0.004	(0.003)		
CDMtil2020							0.003	(0.002) *
GEF_L1-9	0.004	(0.001) ***	0.005	(0.001) ***	0.005	(0.002) ***	0.007	(0.002) ***
Knowledge	-219.10	(111.90) *	-152.21	(93.495)	-149.52	(103.63)	-121.848	(93.551)
Policies							-0.244	(0.199)
L.Policy	0.374	(0.549)			0.105	(0.691)		
L.REPolicy	-0.210	(0.191)						
L.Policy_TEN			-1.074	(0.537) **				
L.Policy_I&S			0.757	(0.687)				
Oil imports	0.327	(0.355)	0.402	(0.351)	0.403	(0.340)	0.422	(0.346)
GDP per capita	-0.022	(0.13)	-0.059	(0.128)	-0.043	(0.136)	-0.053	(0.122)
Nat. resources	11.756	(3.928) ***	12.986	(4.023) ***	12.758	(4.229) ***	12.598	(4.270) ***
ODA	0.510	(0.161) ***	0.518	(0.155) ***	0.514	(0.15) ***	0.001	(0.130) ***
Constant	3.248	(1.638)	2.246	(1.388)	2.118	(1.428)	2.143	(1.333)
Year FE	Yes		Yes		Yes		Yes	
N	164		164		164		164	
Groups	10		10		10		10	
Wald-test	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)
Various stat.	0.36	(AR2, p-value)	0.44	(AR2, p-value)	0.44	(AR2, p-value)	0.51	(AR2, p-value)
Hansen test	1.00	(p-value)	1.00	(p-value)	1.0	(p-value)	1.00	(p-value)
# instruments	238		225		226		224	

Note: Post-2012-CER price of 3 USD per CER assumed, which is roughly the average post-2012 CER price as reported by GTZ (2010) for the period 2005-2008. Not displayed: Endogenous variables in BB: CDM, GEF, ODA, policies; all policy variables entail the number of policies in the lag; TEN = tenders, RPS = Renewable portfolio standards, I&S=Incentives& Subsidies, FIT=Feed-in tariffs

10.2.5 Hydro power: alternative specifications and sensitivity analyzes

HYDRO	Selection model Logit with clustered SE		Blundell-Bond (BB), One step, robust SE , w/o control		Random effects, robust SE		Blundell-Bond (BB) GMM system model, One step, robust SE	
	dy/dx	SE	Coeff	SE	Coeff	SE	Coeff	SE
GEF_L1-3	predicts success. perfect.		0.004	(0.032)	-0.008	(0.006)	0.005	(0.016)
GEF_L4-6	predicts success. perfect.		-0.287	(0.014)	-0.008	(0.028)	-0.007	(0.042)
GEF_L7-9	predicts success. perfect.		-0.012	(0.057)	-0.006	(0.036)	0.012	(0.037)
Year FE			Yes		Yes		Yes	
N	1800		1613		1625		1625	
Groups	121		101		101		101	
F-/Wald-test	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)
Various stats	0.22	(Pseudo-R^2)	0.22	(AR2, p-value)	0.99	(R^2)	0.20	(AR2, p-value)
Hansen test			1.00				0.00	
# instruments			229				522	

Not displayed: Control variables +lagged DV for Random effects and BB; endog. variables in BB: CDM, GEF, ODA, policies

HYDRO	Blundell-Bond GMM system model, One step, robust SE; ***CDM Lag1***		Blundell-Bond GMM system model, One step, robust SE; ***CDM Lag1-2***		Blundell-Bond GMM system model, One step, robust SE; ***GEF Lags 1-6***		Blundell-Bond GMM system model, One step, robust SE; ***GEF Lags 1-2***	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
CDM	0.077	(0.057)	0.033	(0.020)	0.018	(0.014)	0.018	(0.013)
GEF	-0.003	(0.025)	-0.003	(0.025)	-0.009	(0.024)	-0.002	(0.021)
Year FE	Yes		Yes		Yes		Yes	
N	1619		1542		1619		1542	
Groups	1101		1101		1101		1101	
F-/Wald-test	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)
Various tests	0.19	(AR2, p-value)	0.19	(AR2, p-value)	0.19	(AR2, p-value)	0.19	(AR2, p-value)
Hansen test	0.00		0.00		0.00		0.00	
# instruments	505		502		505		500	

Not displayed: Lagged DV + control variables; Endogenous variables: CDM, GEF, ODA, policies

HYDRO	**Fixed effects, bias corrected, bootstrap SE**		**OLS, with clustered SE**		**Fixed effects, robust standard errors**		**Arellano Bond GMM difference model, robust standard errors**	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Lagged DV	1.008	(0.013) ***	0.961	(0.017) ***	0.914	(0.046) ***	0.906	(0.069) ***
CDM	0.012	(0.028)	0.009	(0.012)	0.012	(0.011)	0.038	(0.023)
GEF	-0.010	(0.040)	-0.008	(0.008)	-0.012	(0.011)	0.020	(0.043)
Knowledge	-90.62	(56.881)	-11.620	(10.683)	-86.553	(55.365)	-346.06	(207.1) *
Policies	4.908	(3.090)	12.400	(9.299)	5.958	(6.978)	16.081	(10.60)
Oil imports	0.242	(0.102) **	0.055	(0.059)	0.272	(0.209)	0.444	(0.351)
GDP per capita	4.013	(3.428)	0.021	(0.235)	3.566	(1.863) *	10.794	(9.775)
Nat. resources	-0.018	(9.092)	1.169	(1.667)	0.637	(21.567)	11.744	(31.085)
ODA	-0.445	(0.144) *	0.114	(0.096)	-0.514	(0.502)	-1.796	(1.223)
Constant			2.017	(4.379)	8.835	(34.739)		
Year FE	Yes		Yes		Yes		Yes	
N	1625		1625		1625		1530	
Groups	101				101		100	
F-/Wald-test	-	(Wald, p-value)	0.0	(F-test, p-value)	-	(F-test, p-value)	0.0	(Wald, p-value)
Various stats	-	(R^2)	0.99	(R^2)	0.99	(R^2)	0.22	(AR2, p-value)
Hansen test							0.0	
# instruments							197	

Dependent variable: tonnes of CO_2 reduced with biomass power generation, per million USD of GDP (2007 USD), assuming 500 tCO_2 reduced per GWh of renewable power production; for bias-corrected FE estimator, the xtlsdvc Stata command was used, and the BB estimator was chosen to initialize the bias correction, all independent variables assumed to be exogenous in all models.

HYDRO	Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Lagged DV	0.964	(0.019) ***	0.964	(0.019) ***	0.969	(0.022) ***	0.957	(0.013) ***
CDM	0.018	(0.014)	0.009	(0.023)	0.011	(0.013)	0.007	(0.017)
GEF_L1-9	-0.009	(0.025)	-0.011	(0.025)	-0.021	(0.022)	0.006	(0.037)
Knowledge	-17.550	(12.476)	-15.918	(12.861)			-17.033	(12.781)
Policies	24.603	(18.691)	24.609	(18.912)	24.112	(18.922)	38.992	(33.405)
Oil imports	0.122	(0.153)	0.128	(0.155)	0.135	(0.162)	0.130	(0.163)
GDP per capita	-0.092	(0.260)	-0.117	(0.276)			0.003	(0.371)
Nat. resources	2.766	(2.745)	2.740	(2.711)	2.454	(2.675)	5.176	(4.326)
ODA	-0.587	(0.576)	-0.583	(0.573)	-0.001	(0.001)	-1.378	(0.147)
Kyoto Protocol			1.063	(1.776)				
Electricity use					-3923.1	(2173.0) *		
Financial mark.					6.498	(6.675)		
Develop. loans							-1927.5	(3056.6)
Constant	-2.959	(3.836)	-8.234	(8.829)	0.631	(4.923)	-5.200	(4.983)
Year FE	Yes		Yes		Yes		Yes	
N	1625		1625		1541		1062	
Groups	101		101		98		101	
F-/Wald-test	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)
Various tests	0.20	(AR2, p-value)	0.20	(AR2, p-value)	0.19	(AR2, p-value)	0.23	(AR2, p-value)
Hansen test	1.0		1.0		0.0		0.0	
# instruments	505		506		498		460	

Endogenous variable: CDM, GEF, ODA, development bank loans, policies

HYDRO	Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors;		Blundell-Bond GMM system model, robust standard errors;	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Lagged DV	0.965	(0.019) ***	0.964	(0.019) ***	0.961	(0.018) ***	0.967	(0.021) ***
CDM	0.022	(0.014)	0.014	(0.016)	0.025	(0.016)	0.022	(0.013) *
GEF_L1-9	-0.025	(0.025)	0.001	(0.028)	-0.021	(0.025)	0.001	(0.025)
Knowledge			-21.650	(13.302)	-9.988	(12.714)	-17.951	(10.566) *
Policies	24.577	(18.482)	24.841	(17.410)	24.654	(19.214)	25.196	(19.344)
Oil imports	0.162	(0.169)	0.143	(0.167)	0.115	(0.163)	0.101	(0.141)
GDP per capita	0.737	(0.664)	-0.087	(0.268)	0.162	(0.219)	-0.138	(0.246)
Nat. resources	2.844	(2.753)	2.712	(2.715)	1.224	(2.963)		
ODA	-0.622	(0.597)	-0.593	(0.542)	-0.587	(0.582)	-0.000	(0.001)
3rd education	-0.302	(0.200)						
Oil price			-0.168	(0.188)				
Stability					0.017	(0.008) **		
Nat. res								
Rainfall							0.005	(0.003)
L. Rainfall							-0.004	(0.003)
Altitude							-0.004	(0.011)
Constant	2.406	(5.144)	6.778	(8.712)	-6.158	(4.010)	-2.968	(6.779)
Year FE	Yes		No		Yes		Yes	
N	1625		1619		1612		1625	
Groups	101		101		101		101	
F-/Wald-test	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)
Various tests	0.20	(AR2, p-value)	0.19	(AR2, p-value)	0.21	(AR2, p-value)	0.20	(AR2, p-value)
Hansen test	0.0		1.0		0.0		0.0	
# instruments	505		488		492		507	

Endogenous variable: CDM, GEF, ODA, policies; in specification 4 with lagged national resources, the line "natural resources" does represent the level value of hydro resources and not the level and the lag.

Alternative DV	CO_2 reduction via **RE per capita**		Share of **RE** electricity production		CO_2 reduction via RE per GDP (**country-specific grid factors**)		CO_2 reduction via RE per GDP **(difference to last year)**	
HYDRO	Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Lagged DV	1.049	(0.035) ***	0.885	(0.036) ***	0.922	(0.024) ***		
CDM	-0.001	(0.014)	0.029	(0.033)	0.010	(0.007)	0.021	(0.028)
GEF_L1-9	0.084	(0.126)	0.031	(0.051)	0.086	(0.087)	-0.026	(0.035)
Knowledge	-99.004	(69.852)	-66.015	(24.801) ***	-31.693	(22.325)	-8.469	(14.010)
Policies	24.979	(21.768)	3.633	(5.814)	-0.344	(0.633)	8.430	(10.284)
Oil imports	0.149	(0.185)	0.134	(0.093)	0.054	(0.035)	0.070	(0.126)
GDP per capita	-0.969	(1.149)	0.000	(0.000)	-0.177	(0.103) *	0.199	(0.439)
Nat. resources	5.085	(3.328)	11.007	(4.271) ***	0.605	(0.433)	1.920	(2.914)
ODA	-1.116	(0.959)	0.252	(0.326)	-0.070	(0.084)	0.639	(0.684)
Constant	-23.374	(9.164)	32.981	(18.217)	-1.544	(2.385)	-8.592	(5.223)
Year FE	Yes		Yes		Yes		Yes	
N	1607		1610		1242		1625	
Groups	100		100		78		101	
Wald-test	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)
Various stat.	0.98	(AR2, p-value)	0.36	(AR2, p-value)	0.61	(AR2, p-value)	0.20	(AR2, p-value)
Hansen test	0.00	(p-value)	1.00	(p-value)	1.00	(p-value)	0.00	(p-value)
# instruments	505		494		501		332	

Note: In case of CO_2 reduction via RE per capita, CDM, GEF and ODA are standardized per capita and not per USD of GDP. Not displayed: Endogenous variables in BB: CDM, GEF, ODA, policies

Influence of number of policies in first lag & inclusion of post2012 CER value in CDM variable

HYDRO	Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Lagged DV	0.965	(0.019) ***	0.968	(0.020) ***	0.966	(0.019) ***	0.964	(0.019)***
CDMtil2012	0.024	(0.011) **	0.016	(0.017)	0.026	(0.013) **		
CDMtil2020							0.014	(0.011)
GEF_L1-9	-0.030	(0.031)	-0.029	(0.028)	-0.032	(0.033)	-0.009	(0.023)
Knowledge	-8.571	(12.954)	-22.173	(17.707)	-10.382	(13.445)	-17.571	(12.505)
Policies							24.603	(18.812)
L.Policy	57.806	(50.318)			60.150	(49.998)		
L.REPolicy	-0.751	(4.272)						
L.Policy_RPS			33.709	(27.737)				
L.Policy_I&S			-16.555	(23.433)				
Oil imports	0.103	(0.150)	0.067	(0.081)	0.100	(0.135)	0.122	(0.153)
GDP per capita	0.002	(0.442)	-0.226	(0.244)	-0.055	(0.282)	-0.092	(0.260)
Nat. resources	2.293	(2.112)	3.407	(3.353)	2.302	(2.334)	2.764	(2.748)
ODA	-0.510	(0.503)	-0.393	(0.365)	-0.520	(0.518)	-0.001	(0.576)
Constant	-9.992	(9.713)	-4.433	(4.075)	-13.635		-2.968	
Year FE	Yes		Yes		Yes		Yes	
N	1625		1625		1625		1625	
Groups	101		101		101		101	
Wald-test	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)
Various stat.	0.20	(AR2, p-value)	0.21	(AR2, p-value)	0.20	(AR2, p-value)	0.20	(AR2, p-value)
Hansen test	0.00	(p-value)	1.00	(p-value)	0.0	(p-value)	0.00	(p-value)
# instruments	615		472		498		505	

Note: Post-2012-CER price of 3 USD per CER assumed, which is roughly the average post-2012 CER price as reported by GTZ (2010) for the period 2005-2008. Not displayed: Endogenous variables in BB: CDM, GEF, ODA, policies; all policy variables entail the number of policies in the lag; TEN = tenders, RPS = Renewable portfolio standards, I&S=Incentives& Subsidies, FIT=Feed-in tariffs.

10.2.6 *Solar power: alternative specifications and sensitivity analyzes*

SOLAR	Selection model Logit with clustered SE		Blundell-Bond (BB), One step, robust SE , w/o control		Fixed effects, robust SE		Blundell-Bond (BB) GMM system model, One step, robust SE	
	dy/dx	SE	Coeff	SE	Coeff	SE	Coeff	SE
GEF_L1-3	0.001	(0.001)	-0.000	(0.000)	0.000	(0.000)	-0.000	(0.000)
GEF_L4-6	0.001	(0.001)	-0.000	(0.000)	-0.000	(0.000)	-0.000	(0.000)
GEF_L7-9	0.002	(0.001)	-0.000	(0.001)	-0.000	(0.000)	0.000	(0.001)
Year FE			Yes		Yes		Yes	
N	2009		126		125		125	
Groups	122		13		13		13	
F-/Wald-test	0.0	(Wald, p-value)	0.0	(Wald, p-value)	-	(F, p-value)	0.0	(Wald, p-value)
Various stats	0.12	(Pseudo-R^2)	0.27	(AR2, p-value)	0.84	(R^2)	0.24	(AR2, p-value)
Hansen test			1.00				1.00	
# instruments			164				185	

Not displayed: Control variables +lagged DV for Random effects and BB; endog. variables in BB: CDM, GEF, ODA, policies

SOLAR	Blundell-Bond GMM system model, One step, robust SE; ***CDM Lag1***		Blundell-Bond GMM system model, One step, robust SE; ***CDM Lag1-2***		Blundell-Bond GMM system model, One step, robust SE; ***GEF Lags 1-6***		Blundell-Bond GMM system model, One step, robust SE; ***GEF Lags 1-2***	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
CDM								
GEF	-0.000	(0.000)	-0.000	(0.000)	-0.000	(0.000)	-0.000	(0.000)
Year FE	Yes		Yes		Yes		Yes	
N	125		122		125		122	
Groups	13		13		13		13	
F-/Wald-test	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)
Various tests	0.25	(AR2, p-value)	0.26	(AR2, p-value)	0.26	(AR2, p-value)	0.25	(AR2, p-value)
Hansen test	1.0		1.0		1.0		1.0	
# instruments	173		171		173		167	

Not displayed: Lagged DV + control variables; Endogenous variables: CDM, GEF, ODA, policies

SOLAR	**Fixed effects, bias corrected, bootstrap SE**		**OLS with clustered SE**		**Random effects, robust standard errors**		**Arellano Bond GMM difference model, robust standard errors**	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Lagged DV	0.624	(0.090) ***	0.984	(0.049) ***	0.984	(0.049) ***	0.695	(0.018) ***
CDM								
GEF_L1-9	-0.000	(0.000)	-0.000	(0.000)	-0.000	(0.000)	-0.000	(0.000)
Knowledge	0.028	(0.678)	-0.246	(0.345)	-0.246	(0.345)	0.081	(0.145)
Policies	0.010	(0.029)	-0.010	(0.008)	-0.010	(0.008)	0.005	(0.006)
Oil imports	0.061	(0.086)	0.032	(0.026)	0.032	(0.026)	0.025	(0.026)
GDP per capita	0.002	(0.005)	-0.000	(0.001)	-0.000	(0.001)	-0.004	(0.005)
Nat. resources			0.028	(0.025)	0.028	(0.025)		
ODA	0.004	(0.009)	-0.020	(0.014)	-0.020	(0.014)	0.002	(0.005)
Constant			-0.145	(0.134)	-0.141	(0.136)		
Year FE	Yes		Yes		Yes		Yes	
N	125		125		125		122	
Groups	13		13		13		13	
F-/Wald-test	-	(Wald, p-value)	-	(F-test, p-value)	-	(Wald, p-value)	0.0	(Wald, p-value)
Various stats	-	(R^2)	0.90	(R^2)	0.90	(R^2)	0.26	(AR2, p-value)
Hansen test							1.0	
# instruments							111	

Dependent variable: tonnes of CO_2 reduced with biomass power generation, per million USD of GDP (2007 USD), assuming 500 tCO_2 reduced per GWh of renewable power production; for bias-corrected FE estimator, the xtlsdvc Stata command was used, and the BB estimator was chosen to initialize the bias correction, all independent variables assumed to be exogenous in all models.

SOLAR	Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Lagged DV	0.849	(0.042) ***	0.649	(0.181) ***	0.812	(0.068) ***	0.838	(0.042) ***
CDM								
GEF_L1-9	-0.000	(0.000)	0.000	(0.001)	-0.000	(0.000)	-0.000	(0.000)
Knowledge	-0.190	(0.276)	-0.327	(0.361)			-0.277	(0.340)
Policies	0.004	(0.007)	0.008	(0.008)	0.004	(0.006)	-0.007	(0.009)
Oil imports	0.044	(0.028)	0.029	(0.014) **	0.042	(0.023) *	0.049	(0.031)
GDP per capita	-0.001	(0.001)	0.002	(0.003)			-0.001	(0.001)
Nat. resources	0.041	(0.028)	0.073	(0.042) *	0.043	(0.027)	0.042	(0.029)
ODA	-0.012	(0.011)	0.009	(0.014)	0.008	(0.007)	-0.014	(0.012)
Kyoto Protocol			-0.067	(0.051)				
Electricity use					-9.045	(6.855)		
Financial mark.					-0.051	(0.045)		
Develop. loans							-15.937	(16.80)
Constant	-0.194	(0.142)	0.052	(0.127)	-0.242	(0.161) *	-0.195	(0.144)
Year FE	Yes		Yes		Yes		Yes	
N	125		125		125		101	
Groups	13		13		13		13	
F-/Wald-test	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)
Various tests	0.27	(AR2, p-value)	0.19	(AR2, p-value)	0.28	(AR2, p-value)	0.26	(AR2, p-value)
Hansen test	1.0		1.0		1.0		1.0	
# instruments	173		174		173		146	

Endogenous variable: CDM, GEF, ODA, development bank loans, policies

SOLAR	Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Lagged DV	0.845	(0.037) ***	0.835	(0.066) ***	0.853	(0.031) ***	0.841	(0.030) ***
CDM								
GEF_L1-9	-0.000	(0.000)	-0.000	(0.000)	-0.000	(0.000)	-0.000	(0.000)
Knowledge			-0.229	(0.327)	-0.184	(0.264)	0.114	(0.154)
Policies	0.007	(0.007)	0.009	(0.008)	0.004	(0.008)	0.002	(0.005)
Oil imports	0.046	(0.027) *	0.059	(0.039)	0.042	(0.027)	0.046	(0.028) *
GDP per capita	0.005	(0.004)	-0.003	(0.002)	-0.001	(0.001)	-0.000	(0.002)
Nat. resources	0.026	(0.020)	0.050	(0.037)	0.040	(0.027)		
ODA	-0.011	(0.010)	-0.012	(0.010)	-0.011	(0.010)	-0.012	(0.010)
3rd Education	-0.002	(0.001)						
Oil price			0.000	(0.000)				
Stability					0.000	(0.000)		
Solar_radhoriz							0.058	(0.037)
Constant	-0.103	(0.097)	-0.249	(0.196)	-0.189	(0.135)	-0.281	(0.191)
Year FE	Yes		No		Yes		Yes	
N	125		125		123		125	
Groups	13		13		13		13	
F-/Wald-test	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)
Various tests	0.25	(AR2, p-value)	0.30	(AR2, p-value)	0.26	(AR2, p-value)	0.25	(AR2, p-value)
Hansen test	1.0		1.0		1.0		1.0	
# instruments	173		156		171		173	

Endogenous variable: CDM, GEF, ODA, policies

Alternative DV	CO_2 reduction via **RE per capita**		**Share of RE** electricity production		CO_2 reduction via RE per GDP (**country-specific grid factors**)		CO_2 reduction via RE per GDP **(difference to last year)**	
SOLAR	Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Lagged DV	0.622	(0.094) ***	0.802	(0.054) ***	0.872	(0.043) ***		
CDM								
GEF_L1-9	0.000	(0.000) ***	-0.001	(0.001)	-0.000	(0.000)	-0.000	(0.000)
Knowledge	0.415	(0.067)	-2.182	(2.142)	-0.497	(0.461)	-0.187	(0.215)
Policies	0.005	(0.003)	0.049	(0.058)	0.010	(0.011)	-0.001	(0.005)
Oil imports	0.023	(0.007) ***	0.357	(0.217)	0.078	(0.049)	0.031	(0.017) *
GDP per capita	0.000	(0.001)	0.000	(0.000)	-0.001	(0.002)	-0.000	(0.001)
Nat. resources	0.026	(0.009) ***	0.333	(0.218)	0.072	(0.048)	0.027	(0.016) *
ODA	0.002	(0.002)	-0.106	(0.093)	-0.024	(0.019)	-0.017	(0.007) **
Constant	-0.117	(0.044) ***	-1.540	(1.048)	-0.352	(0.247)	-0.194	(0.142)
Year FE	Yes		Yes		Yes		Yes	
N	125		123		125		125	
Groups	13		13		13		13	
F-/Wald-test	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)
Various stat.	0.06	(AR2, p-value)	0.22	(AR2, p-value)	0.24	(AR2, p-value)	0.27	(AR2, p-value)
Hansen test	1.00	(p-value)	1.00	(p-value)	1.00	(p-value)	1.00	(p-value)
# instruments	172		170		173		101	

Note: In case of CO_2 reduction via RE per capita, CDM, GEF and ODA are standardized per capita and not per USD of GDP. Not displayed: Endogenous variables in BB: CDM, GEF, ODA, policies

Influence of number of policies in first lag & inclusion of post2012 CER value in CDM variable

SOLAR	Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Lagged DV	0.833	(0.054) ***	0.828	(0.045) ***	0.849	(0.044) ***	0.849	(0.042) ***
CDMtil2012								
CDMtil2020								
GEF_L1-9	-0.000	(0.000)	-0.000	(0.000)	0.000	(0.000)	-0.000	(0.000)
Knowledge	-0.080	(0.209)	-0.184	(0.293)	-0.173	(0.274)	-0.190	(0.276)
Policies							0.004	(0.007)
L.Policy	0.013	(0.012)			0.018	(0.014)		
L.REPolicy	-0.006	(0.007)						
L.Policy_FIT			-0.027	(0.019)				
L.Policy_I&S			0.061	(0.038)				
Oil imports	0.052	(0.034)	0.051	(0.032)	0.045	(0.029)	0.044	(0.028)
GDP per capita	0.001	(0.002)	0.000	(0.001)	-0.001	(0.001)	-0.001	(0.001)
Nat. resources	0.043	(0.029)	0.073	(0.046)	0.049	(0.033)	0.041	(0.028)
ODA	-0.015	(0.013)	-0.013	(0.011)	-0.012	(0.011)	0.000	(0.011)
Constant	-0.187	(0.13)	-0.373	(0.245)	-0.247	(0.170)	-0.194	(0.142)
Year FE	Yes		Yes		Yes		Yes	
N	125		125		125		125	
Groups	13		13		13		13	
Wald-test	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)
Various stat.	0.25	(AR2, p-value)	0.25	(AR2, p-value)	0.25	(AR2, p-value)	0.25	(AR2, p-value)
Hansen test	0.00	(p-value)	0.00	(p-value)	1.0	(p-value)	1.00	(p-value)
# instruments	186		170		170		173	

Note: Not displayed: Endogenous variables in BB: CDM, GEF, ODA, policies; all policy variables entail the number of policies in the lag; TEN = tenders, RPS = Renewable portfolio standards, I&S=Incentives& Subsidies, FIT=Feed-in tariffs

10.2.7 *Wind power: alternative specifications and sensitivity analyzes*

WIND	Selection model Logit with clustered SE			Blundell-Bond (BB), One step, robust SE, w/o control			Fixed effects, robust SE			Blundell-Bond (BB) GMM system model, One step, robust SE		
	dy/dx	SE		Coeff	SE		Coeff	SE		Coeff	SE	
GEF_L1-3	-0.000	(0.000)	**	0.003	(0.000)	***	0.003	(0.001)	**	0.003	(0.000)	***
GEF_L4-6	0.000	(0.000)		-0.001	(0.001)	**	0.002	(0.001)	***	0.002	(0.001)	***
GEF_L7-9	predicts success. perfect.			-0.003	(0.001)	***	0.001	(0.001)	**	0.001	(0.001)	
Year FE	Yes			Yes			Yes			Yes		
N	1964			242			240			240		
Groups	122			25			25			25		
F-/Wald-test	0.0	(Wald, p-value)		0.0	(Wald, p-value)		-	(F, p-value)		0.0	(Wald, p-value)	
Various stats	0.16	(Pseudo-R^2)		0.22	(AR2, p-value)		0.92	(R^2)		0.96	(AR2, p-value)	
Hansen test				1.00						0.00		
# instruments				244						310		

Not displayed: Control variables +lagged DV for Random effects and BB; endog. variables in BB: CDM, GEF, ODA, policies

WIND	Blundell-Bond GMM system model, One step, robust SE; ***CDM Lag1***			Blundell-Bond GMM system model, One step, robust SE; ***CDM Lag1-2***			Blundell-Bond GMM system model, One step, robust SE; ***GEF Lags 1-6***			Blundell-Bond GMM system model, One step, robust SE; ***GEF Lags 1-2***		
	Coeff	SE		Coeff	SE		Coeff	SE		Coeff	SE	
CDM	0.001	(0.002)		0.001	(0.002)		0.000	(0.001)		0.000	(0.002)	
GEF	0.002	(0.000)	***	0.002	(0.000)	***	0.003	(0.000)	***	0.001	(0.000)	***
Year FE	Yes			Yes			Yes			Yes		
N	240			237			240			237		
Groups	25			25			25			25		
F-/Wald-test	0.0	(Wald, p-value)		0.0	(Wald, p-value)		0.0	(Wald, p-value)		0.0	(Wald, p-value)	
Various tests	0.28	(AR2, p-value)		0.28	(AR2, p-value)		0.28	(AR2, p-value)		0.28	(AR2, p-value)	
Hansen test	0.00			1.00			1.00			1.00		
# instruments	292			289			292			286		

Not displayed: Lagged DV + control variables; Endogenous variables: CDM, GEF, ODA, policies

WIND	**Fixed effects, bias corrected, bootstrap SE**			**OLS with clustered SE**			**Random effects, robust standard errors**			**Arellano Bond GMM difference model**		
	Coeff	SE		Coeff	SE		Coeff	SE		Coeff	SE	
Lagged DV	1.013	(0.049)	***	1.021	(0.076)	***	1.021	(0.076)	***	0.915	(0.143)	***
CDM	-0.001	(0.001)		0.000	(0.001)		0.000	(0.001)		0.001	(0.002)	
GEF_L1-9	0.005	(0.001)	***	0.002	(0.001)	*	0.002	(0.001)	*	0.002	(0.001)	***
Knowledge	0.667	(2.269)		-0.259	(0.726)		-0.259	(0.726)		-1.145	(0.973)	
Policies	-0.004	(0.063)		0.049	(0.036)		0.049	(0.036)		0.026	(0.037)	
Oil imports	0.814	(0.306)		0.010	(0.022)		0.010	(0.022)		0.114	(0.122)	
GDP per capita	-0.020	(0.104)		-0.003	(0.006)		-0.003	(0.006)		-0.014	(0.031)	
Nat. resources				-0.005	(0.022)		-0.005	(0.022)				
ODA	-0.074	(0.060)		0.035	(0.064)		0.035	(0.064)		0.075	(0.025)	
Constant				0.018	(0.097)		0.436	(0.255)				
Year FE	Yes			Yes			Yes			Yes		
N	244			240			240			237		
Groups	26						25			25		
F-/Wald-test	-	(Wald, p-value)			(F-test, p-value)		-	(Wald, p-value)		0.0	(Wald, p-value)	
Various stats	-	(R^2)		0.94	(R^2)		0.94	(R^2)		0.25	(AR2, p-value)	
Hansen test										1.0		
# instruments										170		

Dependent variable: tonnes of CO_2 reduced with biomass power generation, per million USD of GDP (2007 USD), assuming 500 tCO_2 reduced per GWh of renewable power production; for bias-corrected FE estimator, the xtlsdvc Stata command was used, and the BB estimator was chosen to initialize the bias correction, all independent variables assumed to be exogenous in all models.

WIND	Blundell-Bond GMM system model, robust standard errors			Blundell-Bond GMM system model, robust standard errors			Blundell-Bond GMM system model, robust standard errors			Blundell-Bond GMM system model, robust standard errors		
	Coeff	SE		Coeff	SE		Coeff	SE		Coeff	SE	
Lagged DV	0.972	(0.080)	***	0.971	(0.079)	***	0.978	(0.075)	***	0.970	(0.086)	***
CDM	0.001	(0.002)		0.001	(0.019)		0.000	(0.001)		0.001	(0.002)	
GEF_L1-9	0.002	(0.000)	***	0.002	(0.000)	***	0.003	(0.000)	***	0.002	(0.001)	**
Knowledge	-0.251	(0.737)		-0.347	(0.734)					-0.103	(0.659)	
Policies	0.044	(0.028)		0.039	(0.025)		0.023	(0.026)		0.044	(0.028)	
Oil imports	0.023	(0.028)		0.022	(0.028)		-0.007	(0.036)		0.025	(0.031)	
GDP per capita	-0.004	(0.007)		-0.004	(0.007)					-0.005	(0.007)	
Nat. resources	-0.003	(0.027)		-0.007	(0.029)		-0.012	(0.029)		-0.020	(0.035)	
ODA	-0.005	(0.071)		-0.009	(0.074)		-0.024	(0.068)		0.855	(0.725)	
Kyoto Protocol				-0.014	(0.024)							
Electricity use							-7.914	(20.59)				
Financial mark.							0.203	(0.077)	**			
Develop. loans										-99.391	(59.71)	*
Constant	0.526	(0.268)		0.602	(0.295)	**	0.456	(0.270)	*	0.576	(0.309)	*
Year FE	Yes			Yes			Yes			Yes		
N	240			240			240			204		
Groups	25			25			25			25		
F-/Wald-test	0.0	(Wald, p-value)		0.0	(Wald, p-value)		0.0	(Wald, p-value)		0.0	(Wald, p-value)	
Various tests	0.28	(AR2, p-value)		0.28	(AR2, p-value)		0.28	(AR2, p-value)		0.28	(AR2, p-value)	
Hansen test	1.0			1.0			1.0			1.0		
# instruments	292			293			292			251		

Endogenous variable: CDM, GEF, ODA, development bank loans, policies

WIND	Blundell-Bond GMM system model, robust standard errors			Blundell-Bond GMM system model, robust standard errors			Blundell-Bond GMM system model, robust standard errors			Blundell-Bond GMM system model, robust standard errors		
	Coeff	SE		Coeff	SE		Coeff	SE		Coeff	SE	
Lagged DV	0.970	(0.080)	***	0.975	(0.084)	***	0.961	(0.077)	***	0.973	(0.081)	***
CDM	0.001	(0.002)		0.001	(0.002)		0.001	(0.002)		0.001	(0.002)	
GEF_L1-9	0.003	(0.000)	***	0.003	(0.000)	***	0.003	(0.000)	***	0.002	(0.000)	***
Knowledge				-0.252	(0.676)		-0.684	(0.703)		-0.244	(0.742)	
Policies	0.048	(0.029)		0.068	(0.031)	**	0.061	(0.029)	**	0.043	(0.028)	
Oil imports	0.019	(0.028)		0.024	(0.036)		0.022	(0.032)		0.022	(0.027)	
GDP per capita	-0.003	(0.007)		-0.004	(0.007)		-0.003	(0.006)		-0.005	(0.007)	
Nat. resources	-0.005	(0.028)		-0.006	(0.027)		-0.045	(0.033)		-0.007	(0.072)	
ODA	-0.005	(0.072)		-0.049	(0.068)		-0.002	(0.077)				
3rd Education	-0.001	(0.002)										
Oil price				0.003	(0.001)	**						
Stability							-0.000	(0.000)	**			
%Wind>6m/s										-0.000	(0.003)	
Constant	0.540	(0.276)	*	-0.020	(0.115)		0.745	(0.209)	***	0.397	(0.248)	**
Year dummies	Yes			No			Yes			Yes		
N	240			240			236			240		
Groups	25			25			25			25		
F-/Wald-test	0.0	(Wald, p-value)		0.0	(Wald, p-value)		0.0	(Wald, p-value)		0.0	(Wald, p-value)	
Various tests	0.28	(AR2, p-value)		0.28	(AR2, p-value)		0.27	(AR2, p-value)		0.28	(AR2, p-value)	
Hansen test	1.0			1.0			1.0			1.0		
# instruments	292			275			289			293		

Endogenous variable: CDM, GEF, ODA, policies

Alternative DV	CO_2 reduction via **RE per capita**		**Share of RE** electricity production		CO_2 reduction via RE per GDP (**country-specific grid factors**)		CO_2 reduction via RE per GDP **(difference to last year)**	
WIND	Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors	
	Coeff	SE	Coeff	SE	Coeff	SE	Coeff	SE
Lagged DV	0.925	(0.017) ***	0.896	(0.035) ***	1.129	(0.025) ***		
CDM	-0.001	(0.001)	0.001	(0.006)	-0.002	(0.003)	0.000	(0.001)
GEF_L1-9	0.003	(0.000) ***	0.021	(0.002) ***	0.000	(0.000)	0.002	(0.000) ***
Knowledge	2.559	(4.065)	-3.090	(2.888)	0.293	(0.533)	-0.479	(0.733)
Policies	0.101	(0.143)	0.032	(0.143)	0.086	(0.046) *	0.026	(0.020)
Oil imports	0.113	(0.081)	0.238	(0.146)	0.018	(0.026)	0.020	(0.029)
GDP per capita	-0.005	(0.024)	0.000	(0.000) **	-0.008	(0.005)	-0.003	(0.007)
Nat. resources	0.088	(0.121)	-0.009	(0.123)	0.017	(0.022)	-0.001	(0.028)
ODA	0.284	(0.236)	0.505	(0.389)	-0.070	(0.06)	-0.021	(0.057)
Constant	2.271	(1.274) *	1.423	(0.861) *	0.180	(0.164)	0.517	(0.263) *
Year FE	Yes		Yes		Yes		Yes	
N	240		236		240		240	
Groups	25		25		25		25	
F-/Wald-test	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)
Various stat.	0.27	(AR2, p-value)	0.33	(AR2, p-value)	0.36	(AR2, p-value)	0. 30	(AR2, p-value)
Hansen test	1.00	(p-value)	1.00	(p-value)	1.00	(p-value)	0.00	(p-value)
# instruments	292		288		293		210	

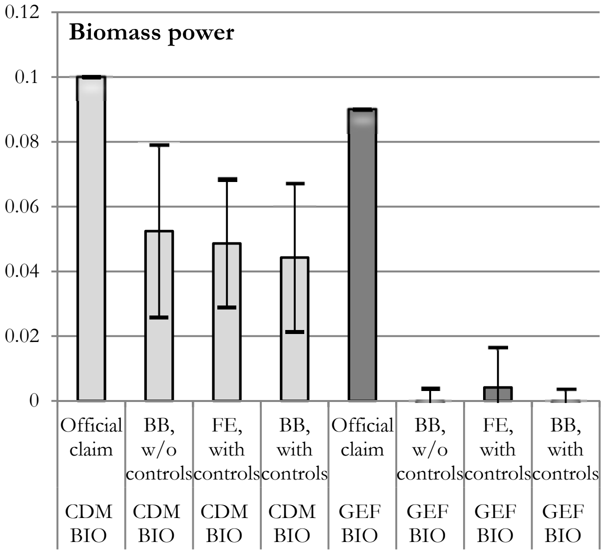
Note: In case of CO_2 reduction via RE per capita, CDM, GEF and ODA are standardized per capita and not per USD of GDP.

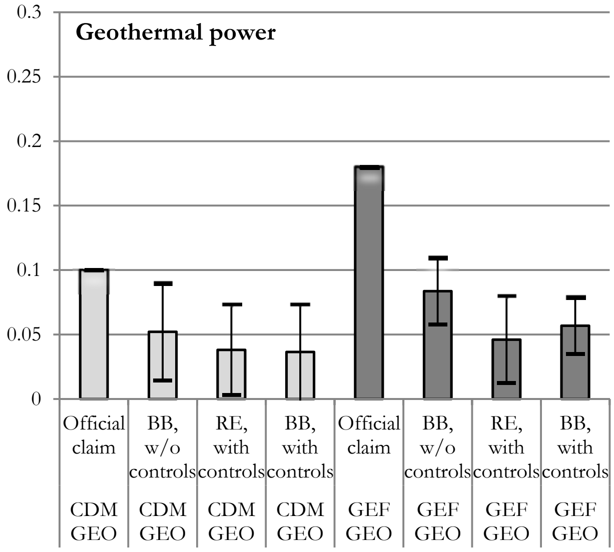
Influence of number of policies in first lag & inclusion of post2012 CER value in CDM variable

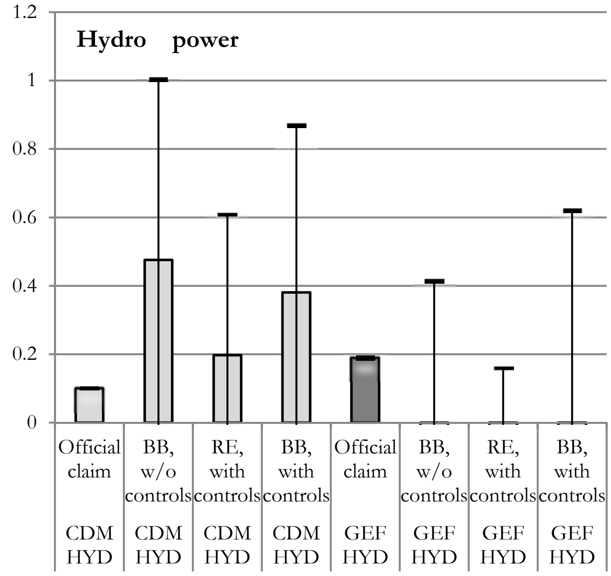
WIND	Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors		Blundell-Bond GMM system model, robust standard errors	
	Coeff	SE SE	Coeff	SE	Coeff	SE		
Lagged DV	0.975	(0.065) ***	0.978	(0.092) ***	0.968	(0.072) ***	0.970	(0.078) ***
CDMtil12	-0.000	(0.001)	0.000	(0.001)	0.000	(0.001)		
CDMtil20							0.001	(0.002)
GEF_L1-9	0.002	(0.000) ***	0.002	(0.000) ***	0.002	(0.000) ***	0.003	(0.000) ***
Knowledge	0.010	(0.780)	-0.616	(0.726)	-0.010	(0.705)	-0.227	(0.733)
Policies							0.041	(0.028)
L.Policy	0.140	(0.084) *			0.165	(0.091) *		
L.REPolicy	0.030	(0.022)						
L.Policy_RPS			-0.043	(0.133)				
L.Policy_TEN			0.400	(0.109) ***				
L.Policy_FIT			-0.127	(0.124)				
L.Policy_I&S			-0.059	(0.071)				
Oil imports	0.016	(0.030) ***	0.004	(0.027)	0.022	(0.031)	0.021	(0.029)
GDP per capita	-0.010	(0.009)	0.001	(0.006)	-0.005	(0.007)	-0.004	(0.007)
Nat. resources	0.010	(0.028) **	-0.009	(0.030)	0.000	(0.029)	-0.007	(0.027)
ODA	0.023	(0.057) *	0.020	(0.072)	0.025	(0.059)	0.000	(0.074)
Constant	0.231	(0.327)	0.536	(0.313) *	0.379	(0.306)	0.517	(0.263) *
Year FE	Yes		Yes		Yes		Yes	
N	240		240		240		240	
Groups	25		25		25		25	
Wald-test	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)	0.0	(Wald, p-value)
Various stat.	0.29	(AR2, p-value)	0.27	(AR2, p-value)	0.28	(AR2, p-value)	0.28	(AR2, p-value)
Hansen test	1.00	(p-value)	1.00	(p-value)	1.0	(p-value)	1.00	(p-value)
# instruments	310		288		288		292	

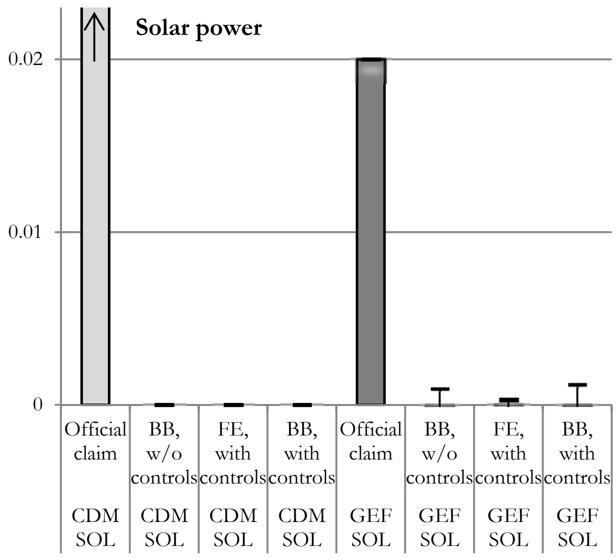
Note: Post-2012-CER price of 3 USD per CER assumed, which is roughly the average post-2012 CER price as reported by GTZ (2010) for the period 2005-2008. Not displayed: Endogenous variables in BB: CDM, GEF, ODA, policies; all policy variables entail the number of policies in the lag; TEN = tenders, RPS = Renewable portfolio standards, I&S=Incentives& Subsidies, FIT=Feed-in tariffs

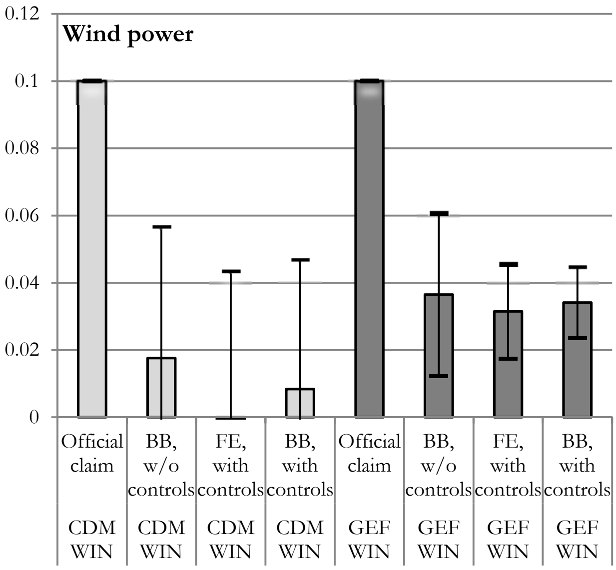
10.2.8 Effectiveness when assuming technology lifetimes according to LDV coefficients in BB model











Notes:
In case of OLS, fixed effects (FE), random effects (RE) and Blundell Bond estimates, the bars show the mean values, while the whiskers indicate the 90% confidence interval. In case where the lower whisker of the 90%-confidence interval is outside the graph, no significant effect has been found. **Values are based on** 500 tonnes of CO_2 reduced per GWh of renewable electricity production, and **technology lifetimes calculated according to the coefficients of the lagged dependent variable in the BB model with control variables (biomass =2.7 years lifetime, geothermal = 8.6, hydro = 21.7, solar = 11.5 and wind =13.7)**.

To make comparison with coefficients possible, the CDM official claim bar shows the effectiveness per USD of funding, whixh is estimated using the same carbon price as in the models - 10 USD per tCO_2).

10.3 Annex to Chapter 6 (Drivers of renewable energy policies)

10.3.1 Coding to assign one regional / trade bloc to each country (used for tradebloc variable)

ASEAN	Brunei Darussalam
ASEAN	Cambodia
ASEAN	Indonesia
ASEAN	Lao PDR
ASEAN	Malaysia
ASEAN	Myanmar
ASEAN	Philippines
ASEAN	Singapore
ASEAN	Sri Lanka Bloc
ASEAN	Thailand
ASEAN	Vietnam
AU	Angola
AU	Benin
AU	Botswana
AU	Burkina Faso
AU	Burundi
AU	Cameroon
AU	Cape Verde
AU	Central African Rep.
AU	Chad
AU	Congo
AU	Côte d'Ivoire
AU	Dem. Rep.of Congo
AU	Equatorial Guinea
AU	Eritrea
AU	Ethiopia
AU	Gabon
AU	Gambia
AU	Ghana
AU	Guinea
AU	Guinea-Bissau
AU	Kenya
AU	Lesotho
AU	Liberia
AU	Madagascar
AU	Malawi
AU	Mali
AU	Mauritius
AU	Mozambique
AU	Namibia
AU	Niger
AU	Nigeria
AU	Rwanda
AU	Sao Tome & Princip
AU	Senegal
AU	Seychelles
AU	Sierra Leone
AU	South Africa
AU	Swaziland
AU	Tanzania
AU	Togo
AU	Uganda
AU	Zambia
AU	Zimbabwe

CARICOM	Bahamas
CARICOM	Barbados
CARICOM	Belize
CARICOM	Dominica
CARICOM	Grenada
CARICOM	Guyana
CARICOM	Haiti
CARICOM	Jamaica
CARICOM	St. Kitts-Nevis
CARICOM	St. Lucia
CARICOM	St.Vincent & Gren.
CARICOM	Suriname
CARICOM	Trinidad and Tobago
CEFTA	Albania
CEFTA	Bosnia-Herzegovina
CEFTA	Bulgaria
CEFTA	Croatia
CEFTA	Macedonia
CEFTA	Romania
CIS	Armenia
CIS	Azerbaijan
CIS	Belarus
CIS	Georgia
CIS	Kazakhstan
CIS	Kyrgyzstan
CIS	Moldova
CIS	Russia
CIS	Tajikistan
CIS	Turkmenistan
CIS	Ukraine
CIS	Uzbekistan
ChiKorMon	China
ChiKorMon	Korea, Republic of
ChiKorMon	Mongolia
ChiKorMon	Taiwan
EU	Cyprus
EU	Czech Republic
EU	Estonia
EU	Hungary
EU	Latvia
EU	Lithuania
EU	Poland
EU	Slovak Republic
EU	Slovenia
LOAS	Algeria
LOAS	Bahrain
LOAS	Comoros
LOAS	Djibouti
LOAS	Egypt
LOAS	Iraq
LOAS	Jordan
LOAS	Kuwait
LOAS	Lebanon
LOAS	Libya

LOAS	Mauritania
LOAS	Morocco
LOAS	Oman
LOAS	Qatar
LOAS	Saudi Arabia
LOAS	Somalia
LOAS	Sudan
LOAS	Syria
LOAS	Tunisia
LOAS	United Arab Emirates
LOAS	Yemen
NAFTA	Mexico
SAARC	Bangladesh
SAARC	Bhutan
SAARC	India
SAARC	Maldives
SAARC	Nepal
SAARC	Pakistan
SICA	Costa Rica
SICA	El Salvador
SICA	Guatemala
SICA	Honduras
SICA	Nicaragua
SICA	Panama
SPC	Cook Islands
SPC	Fiji
SPC	Kiribati
SPC	Marshall Islands
SPC	Micronesia, Fed. Stat.
SPC	Nauru
SPC	Niue
SPC	Palau
SPC	Papua
SPC	Samoa
SPC	Solomon Islands
SPC	Timor-Leste
SPC	Tonga
SPC	Tuvalu
SPC	Vanuatu
UNASUR	Argentina
UNASUR	Bolivia
UNASUR	Brazil
UNASUR	Chile
UNASUR	Colombia
UNASUR	Ecuador
UNASUR	Paraguay
UNASUR	Peru
UNASUR	Uruguay
UNASUR	Venezuela
-	Cuba
-	Dominican Republic
-	Iran
-	Israel
-	Turkey

10.3.2 Full models in comparison with concise models (targets and tariffs)

	RE Targets (concise)		RE Targets (full)		Feed-in-tariffs (concise)		Feed-in-tariffs (full)	
	dy/dx	SE	dy/dx	SE	dy/dx	SE	dy/dx	SE
Domestic energy+	-0.002	(0.001)	-0.002	(0.001)	-0.003	(0.001) **	-0.003	(0.001) **
GDP per capita	0.009	(0.004) **	0.007	(0.004)	0.009	(0.004) **	0.008	(0.004) *
GDP growth	0.055	(0.046)	0.054	(0.049)	0.006	(0.058)	0.001	(0.056)
Population+	0.008	(0.003) ***	0.008	(0.002) ***	0.005	(0.002) **	0.004	(0.002)
Education			0.006	(0.014)			0.004	(0.015)
Hydro resources	0.002	(0.002)	0.003	(0.002) **	0.004	(0.002) *	0.004	(0.002) *
Wind resources	0.000	(0.000)	0.000	(0.000) *	0.000	(0.004)	0.000	(0.000)
Solar resources	0.005	(0.004)	0.006	(0.003)	-0.005	(0.004)	-0.004	(0.004)
Geothermal res.	0.000	(0.000)	0.000	(0.000)	-0.000	(0.000)	-0.000	(0.000)
Biomass res.	0.001	(0.002)	0.001	(0.003)	0.004	(0.002) *	0.003	(0.002) *
Democracy	0.001	(0.000) *	0.001	(0.000)	0.001	(0.001) *	0.001	(0.001)
Pollution (SO2)			0.000	(0.000)			0.000	(0.000)
Civil society org.			-0.001	(0.002)			0.001	(0.003)
Veto players	-0.002	(0.001)	-0.002	(0.001)	-0.001	(0.002)	-0.001	(0.002)
EU member	0.027	(0.014) **	0.027	(0.016) **	0.001	(0.012)	0.000	(0.012)
CEFTA	0.016	(0.009) *	0.014	(0.009) *	0.007	(0.009)	0.005	(0.008)
Common language			-0.010	(0.009)			-0.013	(0.013)
Neighbours	0.012	(0.009)	0.014	(0.010)	-0.012	(0.011)	-0.013	(0.010)
Tradebloc			0.001	(0.018)			0.005	(0.013)
Colony	0.084	(0.039) **	0.790	(0.020)	0.050	(0.026) *	0.045	(0.026) *
CDM projects	0.003	(0.004)	0.003	(0.004) *	-0.004	(0.004)	-0.004	(0.004)
GEF funding	0.004	(0.004)	0.004	(0.005)	0.007	(0.005)	0.007	(0.005)
Development aid	0.007	(0.006)	0.008	(0.005)	0.009	(0.006)	0.009	(0.006) **
Year FE	Yes		Yes		Yes		Yes	
N	1119		1119		935		935	
Years	12		12		10		10	
log likelihood	-140.0		-139.0		-112.1		-111.2	
AIC	339.9		347.9		280.2		288.4	
BIC	490.5		523.7		415.8		448.1	
Pseudo-R^2	0.28		0.28		0.25		0.26	

dy/dx: Marginal effects at mean values of all other independent variables
SE: standard error
Significance levels: * = p-value <0.1, ** = p-value <0.05, *** = p-value <0.01
+ For these variables the 2009 values have been extrapolated.

10.3.3 Full models in comparison with concise models (incentives and framework policies)

	RE Targets (concise) dy/dx	SE	RE Targets (full) dy/dx	SE	Feed-in-tariffs (concise) dy/dx	SE	Feed-in-tariffs (full) dy/dx	SE
Domestic energy+	-0.002	(0.001)	-0.002	(0.001)	-0.004	(0.004)	-0.003	(0.003)
GDP per capita	0.009	(0.004) **	0.007	(0.004) *	0.011	(0.008)	0.011	(0.010)
GDP growth	0.055	(0.046)	0.054	(0.046)	-0.211	(0.152)	-0.204	(0.141)
Population+	0.008	(0.003) ***	0.008	(0.003) ***	0.018	(0.005) ***	0.014	(0.005) ***
Education			0.006	(0.013)			0.036	(0.040)
Hydro resources	0.002	(0.002)	0.003	(0.002)	-0.005	(0.004)	-0.005	(0.005)
Wind resources	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)
Solar resources	0.005	(0.004)	0.006	(0.004)	-0.012	(0.010)	-0.009	(0.011)
Geothermal res.	0.000	(0.000)	0.000	(0.000)	-0.000	(0.001)	0.000	(0.001)
Biomass res.	0.001	(0.002)	0.001	(0.002)	0.000	(0.007)	0.001	(0.007)
Democracy	0.001	(0.000) *	0.001	(0.001) *	0.002	(0.001)	0.001	(0.001)
Pollution (SO2)			0.000	(0.000)			-0.001	(0.002)
Civil society org.			-0.001	(0.003)			0.008	(0.007)
Veto players	-0.002	(0.001)	-0.002	(0.001)	-0.001	(0.004)	-0.001	(0.004)
EU member	0.027	(0.014) **	0.027	(0.014) *	-0.025	(0.049)	-0.004	(0.048)
CEFTA	0.016	(0.009) *	0.014	(0.009)	0.030	(0.028)	0.044	(0.026) *
Common language			-0.010	(0.012)			-0.026	(0.028)
Neighbours	0.012	(0.009)	0.014	(0.009)	0.021	(0.023)	0.020	(0.024)
Tradebloc			0.001	(0.013)			-0.011	(0.049)
Colony	0.084	(0.039) **	0.79	(0.039) **	0.073	(0.040) *	0.075	(0.038) **
CDM projects	0.003	(0.004)	0.003	(0.004)	0.025	(0.018)	0.018	(0.017)
GEF funding	0.004	(0.004)	0.004	(0.004)	0.034	(0.018) *	0.028	(0.017)
Development aid	0.007	(0.006)	0.008	(0.006)	0.009	(0.015)	0.005	(0.014)
Year FE	Yes		Yes		Yes		Yes	
N	938		938		861		861	
Years	10		10		12		12	
log likelihood	-110.5		-109.6		-185.9		-184.0	
AIC	277.0		285.2		431.9		438.0	
BIC	412.6		445.1		574.6		604.5	
Pseudo-R^2	0.29		0.30		0.17		0.17	

dy/dx: Marginal effects at mean values of all other independent variables
SE: standard error
Significance levels: * = p-value <0.1, ** = p-value <0.05, *** = p-value <0.01
+ For these variables the 2009 values have been extrapolated.

10.3.4 Relative importance of domestic and international variables

	RE Targets (concise model)		Feed-in-tariffs (concise model)		Financial incentives (concise model)		Framework policies (concise model)	
	Domestic variables	Internatio-nal variab.	Domestic variables	Internatio-nal variab.	Domestic variables	Internatio-nal variab.	Domestic variables	Internatio-nal variab.
N	1119	1119	935	935	938	938	861	861
Pseudo R2	0.23	0.13	0.19	0.14	0.23	0.17	0.14	0.12
log likelihood	-147.97	-166.36	-121.16	-128.26	-119.65	-129.90	-191.75	-196.82
AIC	341.94	370.71	284.31	290.53	281.29	293.79	429.50	431.63
BIC	457.40	466.09	385.96	372.82	383.01	376.13	538.94	522.04

10.3.5 *Correlation table*

	Target	Tariff	Incentive	Framew.	Dom. En.	GDP p.c.	ΔGDP	Populat.	Educat.	Hydro	Wind	Solar	Geoth.	Biomass	Democ.	Pollution	Civil soc.	Veto play.	EU	CEFTA	language	Neighb.	Tradebloc	Colony	CDM	GEF
Target adoption	1.00																									
Tariff adoption	0.14	1.00																								
Incentive adopt.	0.01	0.20	1.00																							
Framework adopt.	0.35	0.08	0.16	1.00																						
Domestic energy	-0.01	-0.03	0.00	-0.05	1.00																					
GDP per capita	0.08	0.08	0.09	0.04	0.31	1.00																				
ΔGDP (growth)	0.02	0.06	0.05	0.01	0.09	0.05	1.00																			
Population	0.13	0.04	0.12	0.11	0.08	-0.25	-0.02	1.00																		
Education	0.11	0.12	0.11	0.10	0.11	0.77	0.07	-0.12	1.00																	
Hydro resources	-0.04	0.02	0.04	0.02	-0.03	-0.41	0.07	0.19	-0.31	1.00																
Wind resources	0.03	0.02	0.00	-0.02	0.00	0.14	0.02	-0.13	0.28	-0.26	1.00															
Solar resources	-0.08	-0.15	-0.11	-0.10	-0.01	-0.29	-0.25	0.02	-0.50	-0.12	0.13	1.00														
Geothermal res.	0.02	0.03	0.11	0.05	0.08	0.09	-0.03	0.33	0.12	0.19	-0.02	-0.17	1.00													
Biomass resources	-0.02	0.03	0.02	-0.02	0.01	-0.01	0.07	-0.27	-0.06	0.16	-0.14	-0.29	0.07	1.00												
Democracy	0.07	0.11	0.10	0.08	-0.28	0.03	-0.04	0.05	0.19	0.32	-0.10	-0.23	0.17	0.07	1.00											
Pollution (SO2)	0.01	0.01	0.01	-0.02	0.01	0.34	-0.05	-0.15	0.28	-0.40	0.09	0.01	-0.02	-0.11	-0.09	1.00										
Civil society org.	0.04	0.03	0.06	0.08	-0.28	-0.49	-0.01	0.50	-0.32	0.50	-0.25	0.01	0.19	-0.05	0.42	-0.26	1.00									
Veto players	0.12	0.07	0.08	0.08	-0.11	0.02	-0.06	0.21	0.12	0.18	-0.09	-0.18	0.12	0.08	0.60	-0.06	0.33	1.00								
EU member	0.17	0.09	0.15	0.06	-0.01	0.12	0.03	-0.09	0.13	-0.08	-0.05	-0.21	-0.03	0.19	0.10	0.01	-0.06	0.09	1.00							
CEFTA	0.06	0.10	0.07	0.06	0.00	0.21	0.04	-0.07	0.24	-0.01	-0.06	-0.40	-0.08	0.01	0.23	0.06	-0.05	0.17	-0.02	1.00						
Language	0.08	0.02	0.05	0.07	0.09	0.17	0.09	-0.07	0.16	0.02	0.07	-0.07	0.08	0.04	-0.02	0.02	-0.10	-0.06	0.00	0.13	1.00					
Neighbours	0.11	0.10	0.15	0.11	-0.14	0.12	0.12	-0.03	0.24	0.08	-0.01	-0.30	0.02	0.08	0.19	-0.11	0.11	0.05	0.20	0.19	0.45	1.00				
Tradebloc	0.16	0.15	0.14	0.12	-0.05	0.18	0.13	-0.03	0.31	0.13	-0.02	-0.33	0.07	0.13	0.24	-0.02	0.07	0.10	0.20	0.17	0.53	0.61	1.00			
Colony	0.02	0.10	0.01	0.05	-0.13	-0.16	0.06	-0.15	-0.03	-0.15	0.05	-0.04	-0.21	0.00	-0.23	0.00	-0.06	-0.14	0.12	-0.17	0.25	0.17	0.24	1.00		
CDM projects	0.13	0.04	0.13	0.13	-0.06	0.09	-0.02	0.04	0.12	0.14	0.00	-0.03	0.11	-0.02	0.13	-0.01	0.13	0.05	-0.02	-0.05	0.23	0.25	0.40	-0.02	1.00	
GEF funding	0.08	0.10	0.10	0.15	-0.04	0.00	0.03	0.16	0.11	0.10	-0.02	-0.09	0.12	-0.02	0.03	-0.06	0.13	0.05	-0.03	-0.02	0.19	0.15	0.30	0.11	0.23	1.00
Development aid	0.05	0.10	0.11	0.09	-0.05	-0.20	0.10	0.31	-0.04	0.32	-0.10	-0.10	0.15	0.06	0.23	-0.17	0.42	0.13	0.03	0.08	0.13	0.21	0.25	-0.06	0.15	0.17

10.3.6 Coefficients when including diffusion variables separately in models

	RE Targets (concise model)		RE Targets (full model)		Feed-in-tariffs (concise model)		Feed-in-tariffs (full model)	
	dy/dx	SE	dy/dx	SE	dy/dx	SE	dy/dx	SE
Language	0.020	(0.016)	0.003	(0.008)	-0.023	(0.019)	-0.013	(0.015)
Neighbours	0.019	(0.014)	0.009	(0.009)	-0.018	(0.013)	-0.016	(0.011)
Tradebloc	-0.016	(0.031)	-0.000	(0.016)	0.012	(0.018)	0.034	(0.014)
Colony	-0.022	(0.032)	-0.002	(0.018)	0.064 **	(0.031)	0.053 **	(0.028)
Colonizer45[a]	0.017 *	(0.009)	0.012 **	(0.006)	-0.018	(0.013)	-0.014	(0.010)

	Financial incentives (concise model)		Financial incentives (full model)		Framework policies (concise model)		Framework policies (full model)	
	dy/dx	SE	dy/dx	SE			dy/dx	SE
Language	-0.022	(0.022)	-0.014	(0.016)	-0.010	(0.030)	-0.011	(0.027)
Neighbours	0.021	(0.015)	0.018 *	(0.011)	0.017	(0.024)	0.007	(0.022)
Tradebloc	0.018	(0.024)	0.009	(0.016)	0.029	(0.049)	0.005	(0.048)
Colony	0.093	(0.059)	0.095 **	(0.043)	0.069 *	(0.041)	0.064 *	(0.037)
Colonizer45[a]	-0.002	(0.008)	0.002	(0.006)	[b]		[b]	

[a] Dummy whether adoption by post-1945 colonizers; [b] data on adoption of framework policies by colonizer not available

10.3.7 Coefficients of further variables and robustness check for GEF/CDM coefficients (d. = dummies)

	RE Targets (concise model)		Feed-in-tariffs (concise model		Financial incentives (concise model		Framework policies (concise model)	
	dy/dx	SE	dy/dx	SE	dy/dx	SE	dy/dx	SE
Fuirther control variables (Environmental preferences, groups and energy dependence, international diffusion								
Green MPs, d.	-0.006	(0.010)	-0.002	(0.012)	0.001	(0.007)	0.063 *	(0.035)
Green Party, d.	-0.002	(0.004)	-0.001	(0.005)	0.004	(0.004)	-0.016	(0.015)
Protected area[a]	-0.000	(0.000)	0.000	(0.000)	-0.000	(0.000)	0.000	(0.000)
GDPp.c.^{2}	-0.001	(0.003)	-0.000	(0.003)	0.003	(0.002)	-0.006	(0.005)
ENGOs[a]	-0.006	(0.004)	0.001	(0.001)	-0.002	(0.002)	-0.002	(0.004)
Greenpeace	-0.010	(0.007)	0.001	(0.006)	-0.001	(0.004)	-0.023	(0.022)
Diesel price[a]	0.004	(0.007)	0.016 *	(0.009)	0.012	(0.008)	-0.011	(0.021)
Oil price[b]	0.000	(0.000)	0.000	(0.000)	-0.000	(0.000)	0.000	(0.001)
Electricity use	-0.003	(0.002)	-0.000	(0.002)	-0.001	(0.001)	-0.004	(0.004)
ΔGDPxEl-use	-0.017	(0.019)	-0.004	(0.028)	0.028 *	(0.017)	-0.061	(0.057)
FCCC ratif. (y.)	0.002	(0.001)	0.001	(0.001)	-0.001	(0.001)	0.002	(0.003)
Kyoto ratif. (y.)	0.000	(0.000)	-0.000	(0.000)	0.000	(0.000)	0.000	(0.000)
US colony (p45)	0.025	(0.015)	0.007	(0.012)	0.015	(0.011)	0.029	(0.052)
Robustness check for GEF and CDM specifications								
GEF (d.)	-0.006	(0.009)	0.002	(0.007)	-0.001	(0.008)	0.030	(0.021)
L1.GEF (d.)	0.010	(0.007)	0.010	(0.007)	0.006	(0.006)	0.040	(0.025)
L2.GEF (d.)	-0.004	(0.009)	-0.002	(0.008)	0.003	(0.006)	0.039	(0.027)
L3.GEF (d.)	0.011	(0.008)	0.006	(0.008)	-0.002	(0.008)	-0.016	(0.037)
L4.GEF (d.)	0.005	(0.010)	Predicts failure perf.		0.008	(0.008)	0.010	(0.038)
L5.GEF (d.)	Predicts failure perf.		0.010	(0.008)	-0.012	(0.011)	-0.026	(0.047)
L6.GEF (d.)	0.017 *	(0.009)	0.017 *	(0.010)	0.005	(0.009)	Predicts failure perf	
CDM (d.)	0.017 **	(0.008)	0.003	(0.007)	-0.002	(0.006)	0.028	(0.025)
L1.CDM (d.)	0.007	(0.007)	-0.003	(0.007)	0.006	(0.007)	0.067 **	(0.030)
L2.CDM (d.)	0.019 **	(0.009)	-0.015	(0.012)	-0.003	(0.007)	0.032	(0.040)
L3.CDM (d.)	0.012	(0.011)	-0.007	(0.012)	0.011	(0.010)	Predicts failure perf	

[a] Reduces sample size, and data only for 2010 (is assumed to be the same in other years; [b] Here, year dummies are excluded but year (to proxy linear trend) is included; d = dummies, ENGO = environm. NGO, MP = member of parliament; p45 = post 1945; ratif. = ratified; y. = years

10.4 Annex to Chapter 7 (Mobilizing private finance)

10.4.1 *Skewness and kurtosis of dependent variables*

GEF/ CDM	Variable	N	Mean	Standard Deviation	Skew-ness	Skewness (p value)	Kurto-sis	Kurtosis (p value)
GEF	Cost-effectiveness (PD)	101	1.00	2.42	4.75	0.00***	30.82	0.00***
	Ln cost-effectiveness (PD)	89	-1.50	1.96	-0.03	0.90	2.49	0.31
	Cost-effectiveness (EV)	43	1.17	2.92	4.28	0.00***	22.20	0.00***
	Ln cost-effectiveness (EV)	40	-1.80	2.55	-0.53	0.14	2.74	0.99
CDM	Cost-effectiveness (PD)	218	0.47	0.78	3.39	0.00***	16.63	0.00***
	Ln cost-effectiveness (PD)	218	-1.63	1.64	-1.15	0.00***	5.15	0.00***
	Cost-effectiveness (EV)	68	0.32	0.76	5.99	0.00***	42.68	0.00***
	Ln cost-effectiveness (EV)	68	-1.80	2.55	-0.97	0.00***	4.40	0.00***

PD=Project document, EV= evaluations
* = p-value <0.1, ** = p-value <0.5, *** = p-value <0.01

10.4.2 *Pearson's product moment correlation coefficient for GEF covariates*

	cost-effectiveness (PD)	Ln cost-effectiveness (PD)	cost-effectiveness (EV)	Ln cost-effectiveness (EV)	Private investments	Public investments	International grants	National grants	World Bank	Size of the economy	Size of project	Date of approval
cost-effectiveness (PD)	1.00											
Ln cost-effectiveness (PD)	0.65	1.00										
cost-effectiveness (EV)	0.43	0.41	1.00									
Ln cost-effectiveness (EV)	0.47	0.61	0.56	1.00								
Private investments	0.09	0.20	0.18	0.35	1.00							
Public investments	-0.16	-0.13	-0.03	0.29	0.09	1.00						
International grants	-0.11	-0.09	-0.17	-0.04	0.02	0.20	1.00					
National grants	0.07	0.01	0.00	0.17	-0.07	0.10	-0.11	1.00				
World Bank	-0.13	0.03	-0.02	0.24	0.13	0.46	-0.01	-0.18	1.00			
Size of the economy	0.27	0.35	0.63	0.43	0.30	-0.05	-0.20	0.03	0.11	1.00		
Size of project	0.08	0.11	0.36	0.35	0.26	0.17	-0.15	-0.08	0.35	0.57	1.00	
Date of approval	-0.10	-0.15	0.07	0.13	0.07	0.10	0.13	0.20	0.09	-0.03	0.06	1.00

10.4.3 Pearson's product moment correlation coefficient for CDM covariates

	cost-effectiveness (PD)	Ln cost-effectiveness(PD)	cost-effectiveness (EV)	Ln cost-effectiveness (EV)	Private investments	Public investments	Privately owned	Size of the economy	Size of project	Date of approval
cost-effectiveness (PD)	1.00									
Ln cost-effectiveness (PD)	0.65	1.00								
cost-effectiveness (EV)	0.94	0.44	1.00							
Ln cost-effectiveness (EV)	0.59	0.94	0.53	1.00						
Private investments	0.20	0.20	-0.06	0.08	1.00					
Public investments	0.08	0.10	-0.01	0.13	-0.20	1.00				
Privately owned	0.10	0.17	-0.03	0.17	0.45	-0.45	1.00			
Size of the economy	0.01	0.14	-0.06	0.20	-0.11	0.19	-0.38	1.00		
Size of project	0.37	0.22	0.90	0.31	-0.10	0.07	-0.16	0.11	1.00	
Date of approval	-0.12	-0.17	-0.31	-0.34	-0.06	-0.21	0.17	-0.08	-0.16	1.00

10.4.4 Correlation between investment intensity and cost-effectiveness of evaluated projects

GEF	Pearson's pair-wise correlation coefficient Cost-effectiveness (logarithm)	Spearman's rank-ordered pair-wise correlation coefficient Cost-effectiveness (logarithm)
Private investments	0.35**	0.42***

N=40; * = p-value <0.1, ** = p-value <0.05, *** = p-value <0.01

CDM	Pearson's pair-wise correlation coefficient Cost-effectiveness (logarithm)	Spearman's rank-ordered pair-wise correlation coefficient Cost-effectiveness (logarithm)
Private investments	0.08	0.12

N=68; * = p-value <0.1, ** = p-value <0.05, *** = p-value <0.01

10.5 Curriculum vitae of the author

Surname	Stadelmann
Forenames	Martin Nikolaus
Birth	19th June 1981 in Bern, Switzerland
Nationality	Swiss
Place of residence	Konkordiastr. 14, 8032 Zurich, Switzerland
Civil status	unmarried, one child

Education

2001	School-leaving examination equivalent to 3 A-levels
2001 - 2006	Studies in Geography, Economics, Political Science and Philosophy at the University of Bern, Switzerland
2004 - 2005	Studies in Geography and Political Science at the University of Exeter, UK
2006	MSc (Geography). Master thesis on the biogas innovation system in Switzerland
Since 2009	PhD student at the Chair for Political Economy & Development, University of Zurich

Scientific award

2007	Student Award 2007 of the Swiss Association of Energy Economists (for the master thesis)

Academic experience

2003 - 2004	Director of an academic society promoting sustainability in higher education
2003 - 2006	Attending several workshops and courses of the Swiss Study Foundation including Ethics, Corporate Communications, Presentation Techniques, Philosophy of Science.
2006 - 2010	Providing papers to and presenting at several conferences including "Future of Science, Technology and Innovation Policy", University of Sussex, 2006; International Climate Policy PhD workshop, Columbia University, 2009; Carbon Markets Insights, Amsterdam, 2010, Colorado Conference on Earth System Governance, Fort Collins, 2011; Climate Policy Innovation workshop, Cambridge, 2012.
2007	Research assistant at the Center for Innovation Research in the Utility Sector at the Swiss Federal Institute of Aquatic Science and Technology (Eawag)
2009 - 2010	Lecturer of courses on International Climate Policy at the University of Zurich

Professional experience

1996 - 2001	Several temporary jobs (e.g. distributor of newspapers, worker in factories & the supermarket, journalist for sport magazine, private tutor for pupils)
2001 - 2004	Assistant in the map archives of the Swiss Federal Office of Topography
2006 - 2011	Project Manager at the foundation myclimate - Development of several CDM and Voluntary Gold Standard projects (Asia, Africa) - Project visits in South Africa, Madagascar & Indonesia
Since 2007	Attendance at the Conference of the Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC) in Bali 2007, Poznan 2008, Copenhagen 2009 and Cancun 2010. Organization of official side events in Bali and Cancun
2009	Short Term Temporary at the Global Environment Facility, Washington D.C. (analyzing the CO_2 impact of GEF projects)
2011 - 2012	Research and consultation for several governmental institutions on international climate finance: IEA Renewable Energy Technology Development, Swedish Energy Agency, German Environmental Agency, Swiss State Secretariat of Economic Affairs, Agency for Development and Cooperation and Federal Office for the Environment
2011 - 2012	Part of the Swiss delegation at the climate negotiations in Bonn and Panama 2011 (expert for "technology transfer"), and Bonn 2012 (expert for "finance")

Other experience

1999	Official governmental permission to lead a youth camp; main leader of a 2-weeks boy-scouting camp for 40 people
2004 - 2005	100 hours of volunteering work for the British Trust for Conservation Volunteers (BTCV)
2006 - 2008	Head of a 250 person boy-scouting group

Curriculum vitae of the author (continued)

Languages

	Reading & writing	*Listening & speaking*
German	Excellent	Mother tongue
English	Very good (59 of 60 points*)	Very good (56 of 60 points*)
French	Good	Fair - Good
Chinese	-	Beginner
Russian	Beginner	Beginner

* TOEFL test, September 2008.

Publications in peer-reviewed journals

Markard, J., Stadelmann, M., Truffer, B., 2009. Prospective analysis of technological innovation systems: Identifying technological and organizational development options for biogas in Switzerland. In: Research Policy 38(4), pp. 655-667.

Stadelmann, M., Roberts, J.T., Michaelowa, A., 2011. New and additional to what? Options for baselines to assess climate finance pledges. In: Climate and Development, 3(3), pp. 175-192

Stadelmann, M., Persson, A., Ratajczak-Juszko, I, Michaelowa, A., forthcoming. Equity and cost-effectiveness of multilateral adaptation finance - are they friends or foes? Forthcoming in: International Environmental Agreements

Stadelmann, M., Michaelowa, A., Roberts, J.T., forthcoming. Difficulties in Accounting for private finance in international climate policy. Forthcoming in: Climate Policy

Tatrallyay, N., Stadelmann, M., forthcoming. Climate change mitigation and international finance: effectiveness of CDM and GEF in India and Brazil. Forthcoming in: Mitigation and Adaptation Strategies for Global Change

Other Publications (selection)

Butzengeiger-Geyer, S, Michaelowa, A.; Köhler, M.; Stadelmann, M.(2011): Market mechanisms for adaptation to climate change - lessons from mitigation and a pathway to implementation; CIS Working Paper No. 71, Center for Comparative and International Studies, Zurich

Castro, P., Hayashi, D., Kristiansen, K., Michaelowa, A., Stadelmann, M., 2011. Linking RE Promotion Policies with International Carbon Trade. IEA Renewable Energy Technology Development.

Castro, P., Hayashi, D., Stadelmann, M., Michaelowa, A., Cames, M., Healy, S., 2011. Solving the MRV challenge for new market-based mechanisms: What can past experience teach us? Discussion Paper. Oeko-Institut, Berlin.

Ciplet, D., Roberts, J.T., Stadelmann, M., Chandani, A., Huq, S., 2011. Scoring fast-start climate finance: leaders and laggards in transparency, International Institute for Environment and Development, London

Roberts, J.T., Stadelmann, M., Huq, S., 2010. Copenhagen's climate finance promise: six key questions. International Institute for Environment and Development (IIED), London.

Stadelmann, M., Brown, J., Hörnlein, L., 2012. Fast-start finance to address climate change: what we know at the mid-point. In: A. Michaelowa (ed.) Carbon Markets or Climate Finance. Low carbon and adaptation investment choices for the developing world. Routledge, London

Stadelmann, M., Castro, P., Michaelowa, A., 2011. Mobilising private finance for low-carbon development. Tackling barriers to investments in developing countries and accounting of private climate flows. Final report, Climate Strategies, Cambridge.

Stadelmann, M., Castro, P., Michaelowa, A., 2011. Is there a leverage paradox in climate finance? Efficiency of the CDM and the GEF in leveraging funds and reducing CO_2. Working Paper, Climate Strategies, Cambridge.

Stadelmann, M., Eschmann, M., 2011. Country Case Study Peru. Removing barriers for climate change mitigation. Working Paper, Climate Strategies, Cambridge.

Stadelmann, M., Michaelowa, A., 2011. How to enable the private sector to mitigate? Building capacity and creating an enabling environment for low-carbon business activities in developing countries. Working Paper, Climate Strategies, Cambridge .

Stadelmann, M., Roberts, J.T., Michaelowa, A., 2011. Accounting of private climate finance. Types of finance, data gaps and the 100 billion dollar questionFinal report, Climate Strategies, Cambridge.

Tatrallyay, N., Stadelmann, M., 2011. Country Case Study Vietnam. Removing barriers for climate change mitigation. Working Paper, Climate Strategies, Cambridge.